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AUTONOMY OF UNIVERSITIES IN GREAT BRITAIN

THREE memoranda, dealing with the universities and government in Great Britain, with the University Grants Committee, and with Government grants-in-aid to universities in Great Britain, respectively, have been submitted to the Commission on Financing Higher Education, a private agency sponsored by the Association of American Universities. These memoranda have now been published*, with a foreword by J. D. Millett, the executive director of the Commission. The broad conclusion reached is that the British system is unlikely to be suitable for American conditions. On the Federal level, as Prof. Lindsay Rogers points out, the United States is so large and the number of institutions is so great that a single university grants committee would confront an impossible task. Apart from this, both Prof. Rogers and President Dodds are doubtful whether either the Washington atmosphere or local public opinion would be as favourable to the freedom and independence of the universities as both that of Whitehall and public opinion in general are in Great Britain. The risks of State interference are greater in the United States, primarily because of the financial control of the universities and colleges by boards of trustees which are not predominantly academic, and which may be less resistant to external pressure than academic staff would be.

Nevertheless, if this survey of the British system by three independent trained minds yields little by which the United States can profit directly, it is of real value for Great Britain. It is of the greater interest in that the surveys were made prior to the examination of the system conducted by the Select Committee on Estimates during February–March 1952. Its findings thus make an interesting counterpart to those of the Select Committee in its Fifth Report for the Session 1951–52 and also to Mr. H. B. Chubb's scholarly book, "The Control of Public Expenditure". Its importance lies principally in the independent analysis it provides of the conditions responsible for the past success of the system and the factors which may limit its functioning in future. It is accepted that the universities of the United Kingdom will continue to depend chiefly on the Government for financial support. All three authors agree that even with the greatest goodwill toward the universities and with the greatest respect for the tradition of academic freedom, the predominance of government financial support involves, at least indirectly, government guidance of academic policy. The system is one of compromise, the natural method by which toleration works. Toleration and compromise, as Sir Ernest Barker points out in his "Reflections on Government", are the basis of democratic government; and the continuance and the effectiveness of the University Grants Committee system depends

* Government Assistance to Universities in Great Britain. Memoranda submitted to the Commission on Financing Higher Education by Harold W. Dodds, Louis M. Hacker and Lindsay Rogers. (Published for the Commission on Financing Higher Education.) Pp. xiii+133. (New York: Columbia University Press; London: Oxford University Press, 1952.) 16s. net.

accordingly on the continuance of that liberal tradition or spirit of accommodation.

The implications of this situation are well brought out in these memoranda, particularly in those of Prof. Rogers and President Dodds. The system works well in Great Britain because of social and political customs and institutions which are peculiar to the country and may even be peculiar to the institutions concerned; they are not reproduced or reproducible in the United States. Nor can it be assumed that they exist in other institutions for which the adoption of a like device has been suggested. In brief, the independence of the British universities cannot be secured by administrative devices alone. It will last just so long as public opinion is willing that the universities should be autonomous, and how long that will be depends on the good sense and moderation shown by the universities themselves.

The potentialities of conflict between government and universities are recognized, and the memoranda give frank expression to some of the fears and misgivings entertained by the universities. Equally there are comments they would do well to note; particularly, for example, the query whether the agreements reached in private between the University Grants Committee and individual universities in regard to non-recurrent grants take sufficient account of the interests of the whole community, or again whether the amount of such grants may not be influenced too much by the skill or experience of one university rather than another in negotiating or presenting its case. That such a position could arise, particularly in regard to the newer departments, has already been adduced as a reason for continuing earmarked grants in the social sciences until such departments are able to present their case on equal terms with older established departments.

The memoranda support the argument already advanced by the Select Committee on Estimates and accepted by the Treasury in a Memorandum on the Select Committee's report that more information should be supplied to Parliament regarding the spending of these large sums of money. The practical problem is to determine what information is to be supplied, in what form and when. So far as Parliament is concerned, there is the question of supplying this at a stage when control can be effective without infringing the autonomy of the universities, and here President Dodds is inclined to suggest that the principle of greater accountability to Parliament will ultimately prevail.

Whether, in fact, such accountability will infringe the independence of the universities depends, however, on the extent to which the value of academic autonomy is understood and appreciated by Parliament and by the community as a whole. There is an aspect of political education involved here to which the universities might well give more attention. The wider and freer assumption of their regional responsibilities, as urged by Prof. B. Dobrée and 'Bruce Truscot', for example, could help; but so could alumni associations of the type which so impressed the Anglo-American Council on Productivity's team on universities and industry. The recommendation in the report of the latter that the desirability of extending graduate contacts in this way should be explored by British universities may well be even more important, from the point of view of maintaining and extending public understanding and support of the universities, than from that of obtaining financial support from sources independent of the Government.

If the broad conclusion of these studies is accepted, that the success of the University Grants Committee rests fundamentally upon unwritten conventions and the personal and social relations of a homogeneous community of university men, in and out of government, sharing common tastes and a common outlook, the importance of a more strenuous effort to extend the area of public understanding both inside and outside Parliament is obvious. President Dodds is on less certain ground in his remarks as to the effect of developments in secondary education on the universities. His suggestion that the British universities are more specialized than American universities is a little surprising.

University autonomy may be less fortuitous, however, in Great Britain than President Dodds inclines to think; but there can be no doubt that the general climate of opinion is scarcely as favourable to an extension of the device as it was to the initiation and early development of the University Grants Committee. Some of the weaknesses of the existing system emphasized in these studies, notably the staffing of its secretariat, are already receiving attention in consequence of the report of the Select Committee on Estimates; but it is clear that full weight should be given to the factors here emphasized as essential to the working of the system before any detailed proposals are formulated for its extension to other bodies.

The existence of a great reservoir of goodwill in public opinion is perhaps the most important factor, and with the comments in these studies as to the supply of further information about the working of the universities and the expenditure of the Parliamentary grant, the universities, individually and through the University Grants Committee, can scarcely fail to give closer attention to this question of publicity. In fairness, however, it should be pointed out that newsprint is one factor which renders such publicity difficult: full accounts of the development and activities of particular universities in national or local newspapers are likely to reach a much wider public than the most attractive accounts which the University Grants Committee could issue officially.

Such reports could not, of course, replace the official accounts for the purpose of informed discussion in Parliament, for example; but they could assist the growth of public understanding, particularly if well supported by broadcast discussions or talks. For it is a main weakness of the proposals for extending the device which has proved so successful in dealing with the universities to other institutions that, by and large, the necessary public understanding of the situation does not exist. Paradoxically, of course, the existence of such public understanding would minimize or even eliminate the need for some of these proposals.

CAN ECONOMICS BECOME AN EXACT SCIENCE?

Econometrics

By Prof. Gerhard Tintner. (A Wiley Publication in Economics.) Pp. xiii+370. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1952.) 46s. net.

A STUDENT of economics is told, early in his theoretical courses, that his subject is distinguished from the natural sciences by the fact that economic experiments are virtually impossible. The lecturer heaves a sigh of regret and passes on with evident satisfaction to a domain wherein economic concepts are defined and their consequences developed with exquisite acuteness and skill, untrammelled by the awkward necessity of comparing theory with fact except in the end-product.

This is one reason why economics has difficulty in obtaining recognition as a branch of science; but there are several others. Economists almost universally prefer a literary method of exposition, and even the most mathematically minded of them write down an equation in their main text with evident reluctance, preferring to relegate the mathematics to the decent obscurity of an appendix. This not only encourages a degree of prolixity which would not be tolerated in any natural science; it also enables them, by the use of phrases like 'other things being equal', 'in the long run' and 'marginal increments', to avoid writing down their boundary conditions or to count the relations between their variables, and hence to make only the vaguest intuitive approach to questions of the uniqueness and stability of their solutions.

Now it has to be admitted that major experiments in economics are indeed impossible and that mathematical economics has not yet succeeded in telling economists much that they did not already know. There is, nevertheless, a growing feeling that if real progress is to be made the literary method is insufficient. One sees many signs of dissatisfaction with the present state of theoretical economics among economists themselves, as well as among those natural scientists who are drawn into an interest in the subject. There has, for example, been a movement away from the rather indefinite and unmeasurable quantity 'utility' towards the observable 'indifference', and a further movement towards the measurement of consumers' preferences through experimental studies of family budgets. Attempts are being made to measure the flow of production factors around the economic system by studies of national accountancy. Experiments in micro-economics are now possible; and although macro-economics experiments remain a dim dream, the methods of statistics, which are particularly appropriate to situations involving a complex of causation, are increasingly being tried out. The economic air is full of model-building, studies of stochastic equations, problems of identifiability and the like, all of them requiring a mathematical technique for their formulation and a statistical technique for their verification; and at last it is being appreciated that dynamic movements are an essential part of even the elements of the subject and that many apparently static properties, such as stable equilibrium, must be studied in the light of velocities, accelerations or time-lags.

The stage seems to be set for the emergence of a quantitative science of economics. (Whether we call it econometrics or not is a matter of taste.) But the actors seem rather reluctant to appear, and when they do they are not very successful. One reason is that they try to do too much; another is that there are not enough of them with a training in natural science; and a third is that they are apt to trail off on abstract mathematical arguments without holding themselves firmly in sight of the main objective. One cannot altogether blame them. A man with a career to make and a reputation to establish has to publish something, and it is easier to obtain positive results in pure mathematics than in the detection of economic patterns among the very imperfect statistical material which exists to-day.

The purpose of this preamble is to put Prof. Gerhard Tintner's book in a correct setting. It is entitled "Econometrics"; but it is not a text-book of econometrics, simply because in the present state of knowledge there cannot be such a thing; by this I mean that there cannot be a smooth development of a theory of quantitative economics from a set of postulates leading to experimentally verifiable conclusions. What Prof. Tintner has done is bring together a great many of the attempts made by econometricians to quantify parts of their subject and to expound the statistical techniques which are required. The book is in three parts: Part 1 (79 pages) is a non-technical introduction to econometrics; Part 2 (107 pages) is an introduction to multivariate analysis; and Part 3 (146 pages) is entitled "Some Topics in Time-Series Analysis". The relative lengths of these parts are themselves an illustration of the greater emphasis placed on statistical techniques than on the development of a quantified economic theory.

The main substance of Part 1 is contained in the third chapter (there are four altogether) on "Some Illustrations of Econometric Research", in which Prof. Tintner exhibits the type of problem which has been tackled econometrically: for example, Schultz's work on demand and supply analysis, Dean's on cost functions, Douglas's on production functions, Waugh's on utility functions, Leontieff's development of the *tableau économique*, and various models by Haavelmo, Tinbergen and Klein. They are all gallant attempts, and it is unfair to scrutinize the work of pioneers with too critical an eye; but it has to be admitted that they are subject to very severe limitations.

Part 2 consists of three chapters, on multiple regression and correlation, on some applications thereof to multivariate analysis and on stochastic models with errors in the equations. Wherever possible, Prof. Tintner quotes examples of econometric applications, and the chapter on errors-in-equations will be a useful introduction to the abstract treatments which have so far appeared in book form.

Part 3 is a review of developments in the theory of stochastic time-series which has taken place during the past twenty years—trend, Fourier analysis, autocorrelation analysis, stochastic difference equations, correlogram analysis and variate differences. There is an appendix on the elements of matrices and determinants and numerical computation.

One of the most useful features of the book is that Prof. Tintner, who has a very extensive acquaintance with the literature of statistics and econometrics, has given full references to original sources, so that his

book is a useful introduction for anyone who wants to take his studies deeper. Personally, I would have preferred to see those references assembled in an appendix and not given in footnotes. There are so many of them that at times a layer of text seems to float on a heavy substratum of reference, leading to that heckling of the text by footnotes against which protests have been lodged in other spheres. But the references are given, which is the main thing.

Prof. Tintner would, I am sure, be the first to acknowledge the shortcomings of this book, some of which are due to the imperfections of the subject and some to the difficulty of expressing advanced statistical methods in terms which economists can assimilate, and a few of which are his own responsibility. But all students of econometrics will want to read it, and it should do much to widen interest in a frustrating but extremely important field awaiting scientific exploration. M. G. Kendall

PRINCIPLES OF QUANTUM THEORY

Quantum Theory
By David Bohm. (Prentice-Hall Physics Series.) Pp. ix+646. (New York: Prentice-Hall, Inc.; London: Constable and Co., Ltd., 1952.) 45*s*. net.

DR. DAVID BOHM has written a highly individual account of the non-relativistic quantum theory, his aim being to express the known results in terms of comparatively qualitative and imaginative concepts at an elementary level. The emphasis is mainly on the physical interpretation and logical structure of the theory, and the explanations given are unusually thorough. This is not to say that the mathematical development is neglected; the text contains neat derivations of most of the standard results. Altogether the book will be very valuable to the thoughtful student.

The first seven chapters develop the physical formulation of the quantum theory, which is built up rather inductively from the hypotheses of Planck and Einstein, the Bohr orbit theory and de Broglie's wave theory. This involves a careful discussion of the correspondence and uncertainty principles and of the changes produced by the process of observation. Dr. Bohm is successful in conveying the physical picture behind the quantum assumptions.

Chapter 8 is concerned with rather abstract matters. There are a discussion of the concepts of motion and of causes and an exposition of the difficult concept of complementarity. Dr. Bohm develops the interesting parallel between the uncertainties of quantum mechanics and the erratic nature of our thought processes; throughout the book are many biological analogies.

The second part of the book develops the mathematical formalism of wave functions, expectation values and probabilities, and the third part gives the usual solutions of standard problems. Proper importance is given to the classical limit, which is established by the W. K. B. approximation. There is a useful chapter on matrix methods, which are used effectively in various parts of the book, but the Dirac notation is not introduced. Three chapters are devoted to perturbation theory, both stationary and time-dependent. There is also an excellent chapter on scattering theory, which, in keeping with the rest of the book, contains an adequate discussion of the validity of the various approximation methods and of the equivalence of the time-dependent and stationary methods of solution. It is perhaps surprising, in a book of 640 pages, to find no account of relativistic electron theory or of second quantization; even the treatment of the symmetry properties of many-particle wave-functions is sketchy.

That the text is discursive may be judged from the fact that the theory of the hydrogen atom does not appear until p. 345. Wave mechanics is at best a queer business; some readers might be more willing to accept the concept that "the properties of matter are opposing potentialities which become precisely defined only at each other's expense and in interaction with an appropriate environment" if preceded, rather than followed, by the evidence that this point of view does at least lead to agreement with the very precise spectroscopic experiments.

The concluding chapters contain an account of the quantum theory of measurement and include a discussion of the famous paradox of Einstein, Rosen and Podolski which has played such an important part in clarifying our ideas on this subject. This leads on to Dr. Bohm's argument for the orthodox view, which he stresses in many earlier chapters, that the peculiarities of quantum mechanical behaviour cannot be attributed to the effects of hidden parameters acting classically. The argument gains greater interest as later papers show that Dr. Bohm now regards this view as open to question.

K. J. Le Couteur

ADVANCES IN PROTEIN CHEMISTRY

Advances in Protein Chemistry
Edited by M. L. Anson, Kenneth Bailey and John T. Edsall. Vol. 7. Pp. viii+411. (New York: Academic Press, Inc., 1952.) 8.50 dollars.

THIS latest volume of "Advances in Protein Chemistry" is a feast for the physical chemist, for five of the six articles deal with physical methods applicable to the study of proteins, or the results of such studies. This is inevitable, as three of the articles, comprising well over half the volume, deal with various aspects of the fibrous proteins (the structure of collagen fibrils; muscle contraction and fibrous muscle proteins; and the proteins of the mammalian epidermis), and these protein systems have been studied mainly by physical methods. Perhaps the volume is rather overweighted by these related topics.

The articles vary widely in their treatment and complexity. The review entitled "Infra-Red Analysis of the Structure of Amino-acids, Polypeptides, and Proteins", by G. B. B. M. Sutherland writing from Ann Arbor, should be compulsory reading for every honours student studying chemistry, biochemistry or physics; it gives an excellent survey of fundamental principles, methods, results and difficulties. On the other hand, the article on "Muscle Contraction and Fibrous Muscle Proteins" (H. H. Weber and H. Portzehl, of Tübingen) starts simply enough, "Muscle works by alternating between contraction and relaxation", and ends honestly, "Neither the study of

the individual purified proteins of the myofibril, nor the brilliant investigations on the fine structure of the fibril, has led to any well-founded theory as to the nature and mechanism of the structural changes which take place in the contractile particles"; but most of the rest is for the expert only.

A splendid review on "The Arrangement of Amino-Acids in Proteins" is contributed by F. Sanger (Cambridge), who himself has devised and applied many of the methods he describes; the section on methods for the degradation of proteins and their inherent pitfalls is especially welcome. A discussion of nomenclature and symbolism for peptide chains and terminal residues is included. A new structure for vertebrate collagen fibrils, based on parallel, coiled, polypeptide chains (protofibrils) with transverse matching of corresponding chemical structures, is put forward by R. S. Bear (Massachusetts Institute of Technology). Work on the comparative structure and organization of mammalian epidermal cell proteins is discussed by K. M. Rudall (Leeds). Complementary to the article on infra-red spectroscopy, G. H. Beaven and E. R. Holiday (London Hospital) consider the "Ultraviolet Absorption Spectra of Proteins and Amino-Acids", especially the vibrational fine structures revealed by Holiday's 'moving-plate' spectrographic method, and the advantages and problems associated with analytical methods for proteins in terms of their aromatic amino-acid content.

It is a pleasure to see so many British authors featured in this volume—a welcome recognition of British contributions to protein chemistry. One suggestion may be made: the publishers should consider providing, in each subsequent volume, a cumulative list of titles in the whole series.

DESCARTES: THE FATHER OF MODERNITY

Descartes and the Modern Mind

By Prof. Albert G. A. Balz. Pp. xiv+492. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1952.) 63*s.* net.

MOST students of the seventeenth century will know the name of Prof. A. G. A. Balz. During the past twenty years, articles in learned reviews and a recent volume of essays, "Cartesian Studies", on the successors, both friendly and hostile, of Descartes have given us a foretaste of the scholarship and power of analysis which mark this distinguished volume, confessedly the fruit of many years of reflexion and study. Whether one agrees or disagrees with Prof. Balz's interpretation of Descartes, one cannot help being impressed by the sincerity and depth of his analysis, and it is refreshing to read a commentator who has meditated the texts of his philosopher and pondered them until he has wrought for himself and his reader a consistent meaning and interpretation. Prof. Balz does not close his eyes to the many difficulties and inconsistencies in the thought of Descartes, but the gaps he sees are not of his own making; they are, in one sense, inherent in the nature of the problems themselves. Towards the end of his book, he points out how fortunate the pursuers of inquiries concerning physical Nature are, in so far as their undertakings are relatively simple and they can avail themselves of the aid of the mathematicians. "They cannot quite conceal a certain disdain for those who conduct inquiries concerning that lesser mystery, man, whose baffling unity of composition is the very ground of their good fortune." Yet even the man of science may turn upon himself and experience some of the doubt and perplexity of the philosopher. "Those who pursue the physical sciences would do well to look with charity and humility upon those who seek to penetrate the mystery we confront because man is man, and because the conductors of inquiry are men." It is probable, at the present moment, that Descartes would obtain a more sympathetic and intelligent understanding of his problems from men of science than from the majority of philosophers, who would reject, out of hand, both solutions and problems as linguistic fallacies.

The title of this work is a little misleading. Except for the last four chapters, the author is not directly concerned with Descartes and present problems of science and philosophy. It is rather the beginnings and growth of the 'modern mind' which form the main subject of this work, and the concern is with Descartes as the father of 'modernity', at least as a first among equals. Prof. Balz is careful to point out that the transition from medievalism to modernity does not merely mean revolt but also conservation, not only change and destruction but also revision and redirection. The first four chapters are accordingly devoted to a discussion of the Augustinian and Thomistic doctrines, especially the famous distinction of Scientia and Theologia, which set the conditions under which Descartes must seek to launch the search for truth in the sciences. The next section describes this quest for certainty and is, in fact, together with the following section, a detailed analysis and exposition of the epistemological and metaphysical doctrines of the "Meditations". It is impossible, in the limits of a short review, to enter into the many points raised in these closely argued chapters. One original point of exposition may perhaps be mentioned. The name *Cartesius* is used to signify reason itself, and *René Descartes* used to describe the conductor of the inquiry who proposes to report what he has learned from Cartesius. This rhetorical device is used to avoid possible misconceptions which may arise from faults in Descartes's own method and devices of expression being confused with the logical structure and articulation of his philosophy. Given the patience requested by Prof. Balz, I was able to follow the elaborate discussion of the methodical doubt and the *Cogito* with comparative ease. Some readers may become slightly irritated.

The second part of the book is devoted to a discussion of the scientific doctrines of Descartes. It is as though the text commented upon was changed to the "Principia", but the emphasis is still upon the philosophical aspects. The mind–matter or soul–body problem is discussed in great detail, and this is one of the most rewarding sections of the whole work. The texts quoted are well known, but an original thinker throws new light on them without forcing or distorting their meaning.

The volume is magnificently produced, although it is somewhat expensive. Personally, I do not see the need for quoting the French texts in their old spelling, which may puzzle a few readers. Descartes himself was a careless speller and often expressed his complete indifference to orthography. Nothing is lost by modernizing the text.

L. J. BECK

Natural Gas and Natural Gasoline

By Prof. R. L. Huntington. (McGraw-Hill Chemical Engineering Series.) Pp. vii+598. (London: McGraw-Hill Publishing Co., Ltd., 1950.) 68*s*.

ONE of the earlier books on natural gas (Lichty, 1924) is still a favourite to consult on this subject. It is none the less instructive to read a new and up-to-date treatise, in this case extending to natural gasoline, for so much has happened in the evolution of this technology in the intervening time. The author is professor of chemical engineering in the University of Oklahoma where, incidentally, the other book was written. Naturally, appeal is to engineering students taking courses in the production of natural gas from crude oil, condensate, dry-gas fields, and the manufacture of various products from such new materials.

A wide range of cognate subjects is considered. The approach is to some extent academic; but practical field applications are by no means neglected. The course of instruction includes the estimation of gas and gasoline reserves; elements of plant location and design; gathering of raw gas and residue gas; a useful account of cycling efficiencies in the Cotton Valley (La.) gas-condensate reservoir; elements of natural-gas processing; and absorption, distillation, fractionation, dehydration, storage and transportation. That difficult subject, high-pressure pipe-line research, is treated with all the mathematical background necessarily entailed, and then the book concludes with a number of useful and practical appendixes, ranging from current specifications to methods of test.

This is a text-book which can be confidently recommended to oil technologists, both in the making and of ripe experience.

Statistics for Medical and other Biological Students

By L. Bernstein and M. Weatherall. Pp. xii+180. (Edinburgh and London: E. and S. Livingstone, Ltd., 1952.) 18*s*. net.

THE introduction of statistical methods in medicine has to some extent been uphill work, so many practitioners by occupation, tradition and inclination being more concerned with the individual case-study than with the broad survey. It is now generally recognized, however, that the medical curriculum should include some elements of statistics. Drs. L. Bernstein and M. Weatherall have written this text-book on the basis of lectures and practical classes given by them to medical students in the first year of preclinical studies.

The development of the book follows fairly standard lines. Two chapters on scientific method and probability precede a set on frequency distributions and measures of location and dispersion. There follow three chapters on sampling, two on regression and correlation, and introductory chapters on transformations, the analysis of variance, experimental design, therapeutic experiments and the interpretation of observations. Much has had to be omitted, and a great deal more dealt with by passing reference, but these limitations are presumably imposed by the size of the book.

The authors have rightly concentrated on the logic of statistical methods and their use in medicine. The mathematics involved in the derivation of these methods have either been omitted or reduced to the point where they can be mastered by the use of elementary algebra. The result is very readable, and if the book does not carry the medical student as far along the path as a statistician would like to see him go—or as he must go if he needs to use statistical methods himself—it at least points his feet in the right direction and gives him a useful introduction to the statistical problems he will have to face.

Practical Pharmacology

By Prof. J. H. Burn. Pp. viii+72. (Oxford: Blackwell Scientific Publications, 1952.) 12*s*. 6*d*. net.

IT would not be easy to invent at short notice a course of practical work for medical students. The experiments must arouse interest and have some relation to practical medicine; but they must also be fairly simple to perform and not take too long. Such courses grow gradually as the years go by; active teachers try out new methods and add the best of them to their repertoire in the place of older methods which have lost their original importance. The result of this process of evolution is an elaborate set of instructions which is issued to the students and contains the results of the accumulated experience of many years. These courses evolve on parallel lines in different places; but those who are responsible for them are always anxious to profit by the experience of others, and every teacher of pharmacology will be glad to have the chance of learning exactly what is done in the pharmacological laboratory in the University of Oxford, which is justly famous for its technical skill and the variety of its experiments.

Prof. J. H. Burn has written a clear account of eleven experiments on isolated organs, seven experiments on mammals with their circulations (but not their brains) intact, two on frogs and one on man. These experiments are all described in full detail, with clear drawings by Dr. E. M. Vaughan Williams, and a number of beautiful figures showing the results. A few of these experiments have been in all practical courses for a long time; but many of them are quite new, and it is clear that the Oxford pharmacologists have not been resting on their laurels. The book is so beautifully printed on glossy paper that it is a little sad to think that many copies of it will soon be exposed to all the dangers of the laboratory.

Technical Publications, 1947

Pp. xi+499. (New York: Standard Oil Development Co.; London: Esso Development Co., Ltd., 1950.) n.p.

THIS second annual volume of papers, by members of the Standard Oil Co. (New Jersey) and five affiliated organizations in the United States, which were contributed to technical magazines during 1947, bears testimony to the talent and diligence, and also to what the president of the Company in his foreword picturesquely describes as the "aggressive research" of the scientific workers and engineers concerned. The volume is divided into papers on geology and production research, manufacturing research, production quality research, and analysis. The subjects range over the determination of oil in place and connate water; oil in Florida; ambiguity in gravity interpretation; palæogeography of South America; consolidation of sands in oil wells; retorting oil shale by fluidized solids; testing cracking-catalysts; liquid—and vapour—liquid extraction; naphthas from fluid catalyst cracking; butadiene resinous polymers; polymers and viscosity index; pour-depressant treated oils; butyl inner

pneumatic tubes and tyre life; heat conduction in rubber-like polymers; synthetic elastomers as plasticizers for polyvinyl resins; infra-red spectroscopy in analysis of liquid hydrocarbons; determination of aromatics and naphthenes in complex mixtures containing olefins; Deniges reagent test for *tert*butyl and *iso*propyl alcohols; short-cut methods of infra-red analysis; and determination of antioxidants in gasoline. The book includes a challenging essay on the stake of business in American education, and closes with the mention of ninety-five other publications published in 1947 by members of the group.

Journal of the Institute of Metals

Vol. 76, 1949–50. Editor: N. B. Vaughan. Pp. xxvi+796+113 plates. 30*s*. Vol. 77, 1950. Editor: N. B. Vaughan. Pp. xxiv+676+83 plates. 30*s*. (London: Institute of Metals, 1950.)

THESE two volumes contain fifty papers and (Vol. 76) a symposium of eight papers on metallurgical aspects of the hot working of non-ferrous metals and alloys, together with the presidential address, and the Autumn and May Lectures of the Institute of Metals. The range of subjects is wide, and all those connected with the science of metals will find much of interest.

It is instructive to examine the sources of the papers, which may be summarized as follows: British Non-Ferrous Metals Research Association, fourteen; universities of Great Britain, ten; Commonwealth Dominions, six; industrial, six; National Physical Laboratory, four; other British government laboratories, three; and research institutions, two. The symposium contains six papers from industrial sources, and one from the British Non-Ferrous Metals Research Association. When compared with the volumes of pre-war years, the increased output of this last-named Association is remarkable. The growth of the Dominion schools is encouraging, but the relatively small number of papers from British government laboratories is regrettable and may well affect the recruiting of first-class men for these institutions. The universities have maintained their position in difficult circumstances; but I feel that the Institute is failing to secure its proper share of papers dealing with the real fundamentals of the science of metals.

W. HUME-ROTHERY

Smithsonian Logarithmic Tables to Base e and Base 10

Prepared by George Wellington Spenceley, Rheba Murray Spenceley and Eugene Rhodes Epperson. (Smithsonian Miscellaneous Collections, Vol. 118: Publication 4054.) Pp. xiii+402. (Washington, D.C.: Smithsonian Institution, 1952.) n.p.

THIS volume is divided into two equal parts, each consisting of two hundred pages. Every page is divided into three parallel columns containing, respectively, the logarithms of n, $1 + n.10^{-7}$ and $1 + n.10^{-11}$, where n ranges through all integers from 1 to 10,000. Those to base e (denoted by ln) appear in the first part, and those to base 10 (denoted by log) in the second part, all entries being given to twenty-three decimal places. In the tables of common logarithms the characteristics are omitted.

A four-page introduction exemplifies the methods of factorization which are most convenient for use in looking up the logarithm or antilogarithm of any given number. To quote a typical example, in which it is assumed that the computer has access to a calculating machine, one can express π, correct to twenty-three decimal places, as

$$3141 \times 1.0^{3}1886 \times 1.0^{7}8307 \times 1.0^{11}5638,\ 28195,\ 88209 \times 10^{-5}.$$

The first three factors can be converted into logarithms immediately, and the fourth factor is dealt with by replacing $\ln(1 + x)$ by $x - x^2/2$, and converting, if necessary, to a common logarithm in the usual way. By this method a result for $\ln \pi$ or $\log \pi$ is obtained which contains an error of one unit only in the twenty-third decimal place. In computing antilogarithms, it is, broadly speaking, only necessary to reverse the above procedure.

Finally, it may be said that the book is well bound and that the printing, though sometimes a little irregular, is always legible; there seems little doubt that, in the words of the preface, "the tables should be a welcome addition to those already in existence".

J. H. PEARCE

Tensor Analysis

Theory and Applications. By Prof. I. S. Sokolnikoff. (Applied Mathematics Series.) Pp. ix+335. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1951.) 48*s*. net.

IN the first two chapters of this book, Prof. I. S. Sokolnikoff proceeds by way of vectors, linear transformations and matrices to the theory of tensors. The third chapter fulfils a dual purpose: it applies tensor methods to differential geometry, thus enabling the reader to assimilate the technique by applying it in a familiar field, and also collecting geometrical results which will be needed in the last three chapters. These deal with general dynamics, relativity and the mechanics of continuous media. The general dynamics is treated fully; the relativity is intentionally merely a sketch, since so many good accounts are already available. The author's deep interest in the theory of elasticity makes the final chapter exceptionally valuable. First he gives an analysis of deformation, based on the work of Brillouin and Murnaghan; but then, instead of assuming a linear stress–strain relation, he uses thermodynamical ideas to infer a general theory in which the classical linearized theory appears simply as a special case. A very brief note on fluid mechanics ends the chapter.

The exposition is clear and readable, and some exercises for the reader to work on are included.

A New School Biology

By Dr. F. J. Wyeth. Part 1. Pp. viii+310+xvii. 9*s*. Part 2. Pp. viii+311–587. 8*s*. 6*d*. (London: G. Bell and Sons, Ltd., 1952.)

THESE two volumes are stated to be for pupils taking the Ordinary level of the General Certificate of Education; but it is to be regretted that the author has not considered the content nor the spirit of the syllabus, the time allocation nor the age of the pupils.

A book full of heavy type and italics is to be deprecated, since it indicates what must be learnt without reference to understanding. Facts abound, from the mechanism of the jaws of a snake to the minute structure of a diatom; digestion in some detail (with formulæ of proteins) but not a word about diet; everywhere there are details of structure and function, but little attempt to link any of it up with human affairs or make it stimulating.

On the whole, this book provides too much and too strong meat for children.

D. M. REID

STRUCTURE OF ALGAL FLAGELLA

By Prof. W. T. ASTBURY, F.R.S., and Dr. N. N. SAHA
Department of Biomolecular Structure, University of Leeds

As a natural development of our work on the molecular structure of bacterial flagella, we have for some time now been engaged also in a similar study of algal flagella. Since this is likely to be long and involved, we believe it will be of value to set down without further postponement some of the findings, which have turned out to be so different from what was rather hoped from the relatively clear-cut results of the bacterial investigation. It will be recalled that the latter placed the essential substance of bacterial flagella (*Proteus vulgaris* and *B. subtilis*) in the keratin – myosin – epidermin – fibrinogen group of fibrous proteins and correlated the motility mechanism with the well-known folding and unfolding of polypeptide chains which is the basis of the long-range elastic properties of the group[1]. It was suggested, in fact, that bacterial flagella can be described as monomolecular hairs or muscles, a conclusion that has since been refined by the deduction from detailed analysis of the X-ray data that a more apt description still would be monomolecular *muscles*[2]. There is a large gap in size and apparent level of complexity between bacterial and algal flagella, as is at once evident from Fig. 1, an electron micrograph of a flagellum of *Euglena gracilis* showing also (inside the loop) a short length of a typically wavy bacterial flagellum about 120 A. thick; but even so, considering the much greater jump between bacterial flagella and hairs and muscles, it seemed not unreasonable to expect that algal flagella too might be found to fit just as readily into the scheme. However, present indications, while not of course ruling out the common broader molecular principles of biological elasticity and movement, are against the idea of any direct conformity with hairs and muscles, as will appear in what follows.

The algal flagella we have examined so far are of *Polytoma*, *Polytoma* 13, *Polytoma* 2a, *Polytomella magna*, *Chlorogonium elongatum*, *Euglena gracilis* and *Chlamydomonas*, pure strains of which, together with much valuable advice for which we are greatly indebted, were supplied by Dr. E. G. Pringsheim, of the Botany School, Cambridge. The flagella were detached, purified and collected by a combination of Gard's[3] shaking technique and centrifugation, and yields were obtained of about 5 mgm. per litre. These have been sufficient for our exploratory purposes; but a total of some 200 mgm. proved a severe limitation in the end, and it becomes necessary to work on a larger scale, as indeed we are now doing.

There are wide structural differences among the various kinds of algal flagella as seen in the electron microscope; but in spite of these differences, their X-ray diagrams are all more or less of the same type, revealing a main component common to them all. It was not found possible to make thin coherent films like those given by sols of bacterial flagella; the films obtained by deposition and drying of algal flagella, though hygroscopic, are brittle and only slightly oriented. Fig. 2, of *Chlorogonium* flagella, is an example of the best we have been able so far to accomplish in this respect—it is unfortunately little better than a powder diagram, albeit a surprisingly good one from such material.

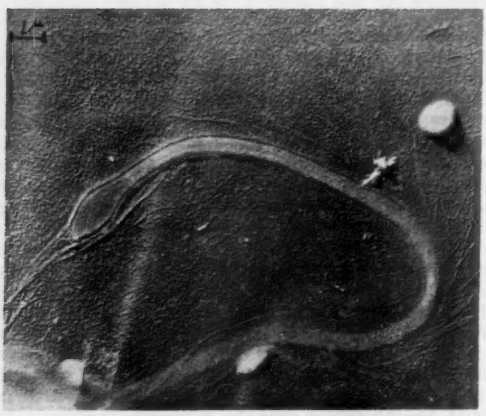

Fig. 1. Electron micrograph of a flagellum of *Euglena gracilis*, showing also, for comparison, a short length of a wavy bacterial flagellum

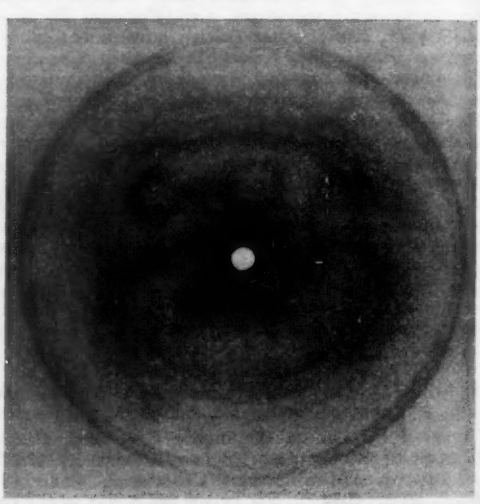

Fig. 2. X-ray diagram of a film of *Chlorogonium* flagella taken with the beam parallel to the plane of the film

In searching for an interpretation of this diagram, we have been struck by a remarkably close matching with probably half a dozen spacings in the diagram given by the polysaccharide xylan (see Fig. 3). This seemed scarcely a coincidence, and we asked Prof. E. L. Hirst, of Edinburgh, to try a chemical analysis on the very small weight of flagella with which we were able to provide him. However, he could detect no xylose nor any other carbohydrate in appreciable amount; but on the other hand, he reported that paper chromatography disclosed the presence of plenty of amino-acids. Dr. W. R. Middlebrook of this Department then repeated the analyses for protein and confirmed the presence of aspartic acid,

X-RAY REFLEXIONS FROM ALGAL FLAGELLA

Spacing (A.) Obs.	Calc.	Intensity	Proposed indices
14·3	(14·3)	s	001
7	(7)	vw–w	010, 002
5·3	5·21	vw	111
5	5·0	vw	012
4·65	(4·65)	s	200
4·1$_4$	4·24	w	103
3·9	3·87	s	210
3·5	(3·5)	m	020
3·1$_4$	3·15	w	022
2·9$_6$	2·98	m	122
2·8$_3$	2·80	s	220
2·6$_3$	2·69	w	123
2·4$_6$	2·41	w	223
2·3$_3$	2·33	w	030, 400
2·0$_9$	2·09	m	230
1·9$_3$	1·93	m	420

glutamic acid, lysine, arginine, glycine, alanine, valine, leucines, phenylalanine, methionine, serine and threonine; the acidic amino-acids predominating over the basic. He too was unable to demonstrate any carbohydrate, though it is felt that this is not a final verdict because of difficulties associated with the simultaneous presence of protein breakdown products. Dr. Middlebrook made also a couple of preliminary estimations of the nitrogen content, but he found only about 8 per cent; so very probably it requires something in addition to simple protein to account for the whole of the flagellar mass.

Our best X-ray diagrams (from *Polytoma* and *Chlorogonium*) show reflexions at the spacings given in the first column of the accompanying table.

These do not appear to correspond particularly closely with anything already familiar in either the protein or polysaccharide field, but in view of the largely protein nature of the flagella and present doubts about polysaccharide, we should like to suggest that the X-ray data accord best with a β-protein structure in a rectangular unit cell of dimensions: $a = 9{\cdot}3$ A., $b = 7$ A. (fibre axis), and $c = 14{\cdot}3$ A. It will be seen from the table that the agreement is quite good. The proposed structure diverges from that of β-keratin and denatured proteins in having (like silk fibroin) an amino-acid spacing of 3·5 A. instead of 3·33 A., and an unusually large side-chain spacing of 14·3 A. instead of 9·8 A. We have, of course, tried to substantiate this choice of axes by repeated efforts to produce sufficient orientation in the flagellar films, but so far with little greater success than to concentrate the 14·3-A. reflexion on the equator of photographs taken with the X-ray beam parallel to the plane of the film—a result which is by no means conclusive on its own, but which is distinctly favourable in combination with another observation made on a thin film that had been dried at 105° in the course of intramolecular swelling tests (see below). When this film was photographed with the beam first perpendicular and then parallel to its plane, it was noticed that the reflexion at 4·65 A. was a little stronger, and that at 14·3 A. a little weaker, in the former diagram, suggesting that the 4·65-A. spacing tended to lie parallel to the film, whereas the 14·3-A. spacing tended to stand perpendicular to it.

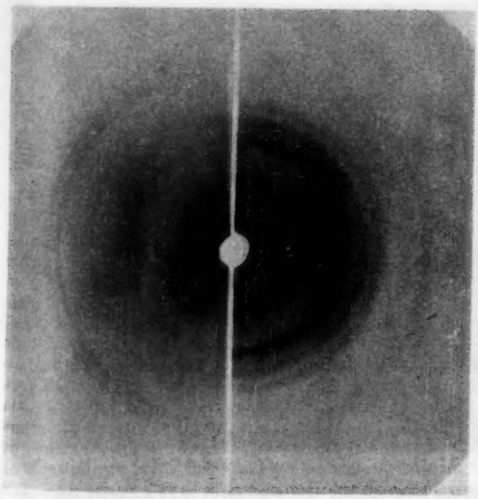

Fig. 3. X-ray comparison of *Polytoma* flagella (left) with xylan (right)

As just mentioned, we have also tried to demonstrate differential intramolecular swelling of the postulated side-chain spacing, but again without success. Contrary to expectation, no change at all could be detected in this respect between dry and wet flagella.

A considerable part of the flagellar substance is soluble in aqueous ammonia (0·1 *M* was used), and it was found then, after centrifuging, that preparations made from the supernatant gave once more practically all the original reflexions; while the insoluble residue gave a much poorer diagram, still similar though, but with greatly weakened side-chain and backbone reflexions and a moderate new reflexion at about 9·6 A.

Complementary experiments to those with ammonia were carried out by adding a few drops of *N* hydrochloric acid to a small amount of flagella on a glass slide and leaving to dry. The X-ray photograph of this sample now showed two kinds of reflexions, one very 'spotty' such as may be obtained from salts and other substances of low molecular weight, and the other continuous rings which proved on closer examination to be strengthened counterparts of certain extremely weak reflexions in the original flagellar diagram. On adding ammonia, this change brought about by acidification tends to be reversed, the 'spotty' rings gradually disappearing and those of the ammonia-soluble structure coming back again.

Another curious result was obtained after heating a sample of wet flagella to about 95° to see whether the orthodox β-diagram of heat-denatured proteins would be produced. What happened was that certain 'spotty' rings appeared quite close to the positions of some of the original continuous rings, as if there were being generated a product of small molecular weight structurally related to the β-protein.

From the above tests (all performed on quantities of material too small for anything like completeness) we have gained the impression, first, that the full diffraction diagram possibly arises from more than one component, and secondly, that the protein side-chains are probably combined with, and perhaps cross-linked through, accessory atoms or groupings. Actually, the 'spotty' (low molecular-weight) lines found after the action of hydrochloric acid show a fair correspondence with the strongest lines in the powder diagram of $CaCl_2,2H_2O$, so it may be that the acid liberates carboxyl groups cross-linked through calcium or other divalent ions. An alternative

explanation that the acid hydrolyses the protein seems excluded by the reversibility of the effect when ammonia is added.

We are indebted to Mr. K. D. Parker of this Department for a number of helpful observations made by infra-red spectroscopy. The absorption spectrum of a thin film of *Chlorogonium* flagella shows the expected general resemblance with that of dried stretched horse-hair (β-keratin); but it is at once apparent that additional factors have to be invoked to account for the former in detail (see Fig. 4). For example, in the region where β-keratin gives the bands at 1,625 cm.$^{-1}$ and 1,650 cm.$^{-1}$ associated with the C=O stretching mode, and the bands at 1,520 cm.$^{-1}$ and 1,550 cm.$^{-1}$ probably due to the NH deformation mode, the flagella give a relatively smooth hump together with a strong band at about 1,400 cm.$^{-1}$. On acidification with hydrochloric acid the latter is eliminated, a depression appears round about 1,600 cm.$^{-1}$ with the result that the CO and NH bands are now unmasked, and a strong band appears at about 1,730 cm.$^{-1}$ together with increased absorption in the region 1,250 cm.$^{-1}$. Strong absorptions at 1,740 cm.$^{-1}$ and 1,250 cm.$^{-1}$ are known to be associated with un-ionized COOH groups, in contradistinction to bands at 1,600 cm.$^{-1}$ and 1,400 cm.$^{-1}$ associated with ionized COO^- groups; so one difference at least between the flagellar protein complex and β-keratin would seem to lie in a relative abundance of carboxyl groups in the former (cf. the predominance of acid amino-acids in the chromatogram after hydrolysis). This inference was further strengthened by comparisons with sodium alginate and alginic acid, which showed very strikingly the change-over just mentioned from ionized COO^- groups to un-ionized COOH groups[4]. A small effect of a similar kind was also observed on treating horse-

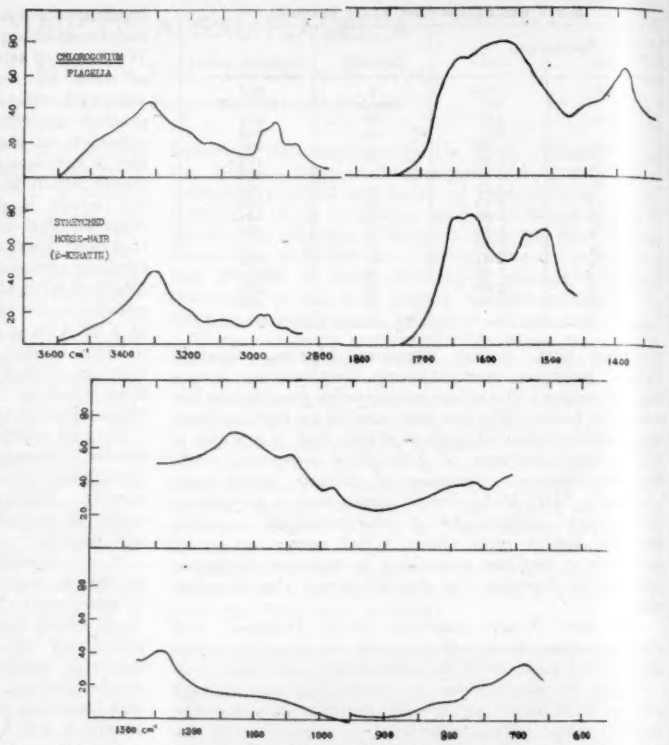

Fig. 4. Infra-red absorption spectrum of *Chlorogonium* flagella compared with that of stretched horse-hair (β-keratin)

Fig. 5

Fig. 6

Fig. 5. Electron micrograph of a flagellum of *Polytomella magna* splitting longitudinally into nine fibrils, with incipient transverse disintegration also

Fig. 6. Electron micrograph of a coiled-up flagellum of *Polytomella magna*

hair with hydrochloric acid. Incidentally, the flagellar spectrum was found to have little in common with that of xylan except for absorption in the region 950–1,200 cm.$^{-1}$, where xylan has strong bands characteristic of carbohydrates. This might be an additional suggestion of the presence of sugar rings of some kind in the flagella. Another noteworthy observation in what looks like the same connexion was made in a comparison of the ammonia-soluble component with the insoluble residue: as with the X-ray comparison described above, the infra-red spectrum of the soluble product was similar to that of the original material, but the insoluble residue showed an increased absorption from about 950 cm.$^{-1}$ to 1,200 cm.$^{-1}$ relative to the absorption from about 1,500 cm.$^{-1}$ to 1,700 cm.$^{-1}$.

Several workers have reported already on electron microscope studies of various flagellates[5], and we ourselves, with the help of Mr. A. Millard, have been content so far with a limited number of micrographs largely for purposes of guidance in the preparative techniques and in relation to the deeper molecular aspects. As noted near the beginning of this article, there are seen in the electron microscope differences in gross morphology that must be secondary to the essential molecular unity indicated by X-rays. An important feature frequently observed is, of course, the longitudinal splitting characteristic of fibre structure. Fig. 5, for example, shows the disintegration of *Polytomella magna* into nine principal fibrils (the original flagellum being about 2,500 A. thick and each fibril about 350–375 A. thick), though this is soon accompanied also by transverse breakage. In some pictures of *Polytoma* the longitudinal splitting is seen to be proceeding to finer threads still; and another common observation is of the tight bending, illustrated in Fig. 6, that appears to be brought about particularly on washing with distilled water. Altogether, what with this coiling-up and eventual longitudinal splitting and transverse disintegration too, it is not surprising that films of such flagella should be so brittle and unresponsive to orientation techniques.

It is tempting to speculate on the molecular basis of the motility mechanism; but the data are not enough yet for any really convincing argument, especially in view of the seeming wide dissimilarity from bacterial flagella. There is nothing in the available evidence in favour of a quasi-rigid flagellum beating about a hinge near its insertion, and we have to find some counterpart to the transition between the α- and super-contracted states to which we have ascribed the bending movements of bacterial flagella. Probably the best guess for the present is that there is a β-structure normally stabilized by cross-linkage of carboxyl groups through calcium or other divalent ions, and that the cross-linkage is periodically broken down, for example, by exchange with monovalent ions. This would give the chains a freedom of movement that could result in an entropic shortening, as in the experiments described by Mongar, Wassermann and MacArthur[6]. These authors observed contractions of up to 20 per cent when calcium alginate fibres were treated with solutions of sodium or other monovalent metal salts. To cause a flagellum to bend into the required form, the interchange between extended and shortened chains would, of course, have to be suitably distributed, in both time and place, among sub-units of the structure; but there is no obvious difficulty about that, considering the way each flagellum is built up from finer fibrils. Sufficient of the latter are recognizable in some kinds of flagella to provide a framework not merely for a side-to-side beating movement but also, if necessary, for a continuous spiral wave.

The idea of chain-molecules normally held straight by cross-linkages is supported by the sharpness of the supposed side-chain reflexion, its unusually high spacing, its unchanged character on wetting, and the chemical evidence for something in addition to simple protein; while the X-ray suggestions of calcium already mentioned are strengthened by spectrochemical tests kindly carried out for us by Dr. R. L. Mitchell, of the Macaulay Institute for Soil Research, Aberdeen. He found, among traces of other metals, a fair amount of sodium, calcium and magnesium, with a relatively small amount of copper, though unfortunately the sample of flagella we were able to send him was too tiny for reliable quantitative estimations.

We are now proceeding to remedy this trouble of having too minute quantities of material, and we hope to be in a position shortly to re-investigate with much more thoroughness all the points and possibilities raised in this preliminary article. At the least, however, it will be granted that we have caught a glimpse of a most fascinating new field in molecular biology that invites exploration with all the intensity and resources at our command.

[1] Astbury, W. T., and Welbull, C., *Nature*, **163**, 280 (1949). Astbury, W. T., *Nature*, **167**, 880 (1951); *Sci. Amer.*, **184**, 21 (1951); *Pubbl. Staz. Zool. Napoli*, **23**, 1 (1951, Suppl.).

[2] Astbury, W. T., Beighton, E., and Welbull, C. (in preparation).

[3] Gard, S., *Arkiv Kemi*, **19**, A, No. 21 (1944).

[4] cf. also Rowen and Plyler, *J. Res. Nat. Bur. Stand.*, **44**, 313 (1950).

[5] See, for example, Manton, I., and Clarke, B., *Nature*, **166**, 973 (1950), together with other references there quoted.

[6] Mongar, J. L., and Wassermann, A., *Nature*, **159**, 746 (1947). MacArthur, I., Mongar, J. L., and Wassermann, A., *Nature*, **164**, 110 (1949). MacArthur, I., and Patnaik, B., *Proc. Leeds Phil. Soc.*, **5**, 254 (1949).

CHINESE SCIENCE REVISITED (2)

By Dr. JOSEPH NEEDHAM, F.R.S.

IN the second of these two articles, the attempt will be made to indicate some of the particular emphases which exist in the Chinese scientific world of to-day. There is, in the first place, an emphasis on practical tasks. In a country where so much modernization has been needed, this is inevitable; but it does not mean that theoretical studies are being neglected, for they are fed by practical experience, and the latter alone, it is felt, can keep them along the right lines. Secondly, there is an emphasis on teaching, since the need for properly qualified specialists (or 'cadres' as they are called) is so pressing. Thirdly, there is an emphasis on popular enlightenment, and the bringing of science and the scientific outlook to the vast masses of the people. Lastly, something should be said about the philosophy of science and the kind of researches which have been noteworthy in the past three years.

At the end of the last article there was mention of geological survey parties—eighty-three of these were in the field during 1951. But the geologists have also given essential service in the physio-topographical surveys of areas where railway construction and river conservancy work are progressing. Without them the Lunghai railhead would not have reached Lanchow ten months ahead of schedule, as it did; without

them the astonishing progress could not have been made with the Huai River Project. In this scheme, which will solve the problem of a great river (between the Yangtze and the Huang Ho) for generations to come, sixteen large retention-basin dams are being constructed on the upper tributaries in the provinces of Honan and Anhui. Some are already finished, and the whole project will be at least on the scale of the famed Tennessee Valley Authority.

In other cases, parties of scientific men of very varied specialities have taken the field. For example, a party of no less than fifty experts proceeded to Lhasa to see what could be done to assist the Tibetans in improving their conditions of life. This group included agronomists, soil scientists, geologists, geographers, meteorologists, sanitary engineers and medical men, ethnologists (for example, Li An-Chê) and historians. Another large party, including gynæcologists and child welfare experts, visited the minority peoples of Sinkiang.

The current emphasis on practical tasks can be seen in all fields. In some, the results produced can be spectacular. The cotton aphid (*Aphis gossypii* Glover) has long been a great pest in the cotton-growing regions of southern Hopei and the newly-formed province of P'ing-Yuan. But its life-cycle was not well understood. After several months of travel and research in the regions concerned, Chu Hung-Fu and his colleagues of Academia Sinica were able to ascertain that this aphid passes the winter attached underground to the roots of a common weed *Lactuca* or *Ixeris chinensis versicolor*. It is now possible, therefore, to eradicate it almost completely; this is all the more important a discovery because the pest is rather resistant to known insecticides. While I was visiting the Academy's Entomological Laboratory, reports came in of the first successful large-scale use (1951) of gamma benzene hexachloride against locusts, spread from aeroplanes in southern Hopei and Anhui. Many of the new substances for insect control, such as *E*-605,666, 'Gammexane', etc., are now made in China.

As for the emphasis on teaching, it can be seen in all fields. For the time being, research is concentrated rather in the institutes and laboratories of the Academy, though it goes on to a minor extent in university laboratories; this is regarded as a passing phase, for the general principle that the latter should also be active research schools is fully admitted. Planned expansion in geology, for example, is remarkable—where there were 35 students in 1951, there were 120 last year, and for this year 1,000 are being planned for. The Medical College of Peking University, and the National Medical College at Shenyang (Mukden), formed by the additional absorption of the former Scottish and Japanese schools, are indeed impressive in their size and vitality. According to Dr. Hu Chuan-Kuei, principal of the Peking University Medical College, which has forty years of history, the student numbers rose from 400 in Kuomintang times to 1,400 at the present day. This includes 260 students in pharmacy, 160 in dentistry, 140 in public health, 40 in nursing and 40 in midwifery. The total number of qualified medical men in China is of the order of 50,000; but ten times this number are urgently needed to give one per thousand of the population. Of the 2,300 hsien cities in China, however, already more than 1,800 have their own State clinic or hospital. Besides the mobilization of old-style practitioners as auxiliaries, already mentioned, there has been a cutting down of the total time needed to qualify. The full qualification will still take five years; but medical assistants are being turned out after a two-year course, and technicians of various kinds need even less. The compression of the curriculum has been done by omission of matters which are unlikely to be met with by the Chinese medical man, for example, the tropical diseases of South America. All teaching is now done in the Chinese language. I saw, as evidence of recent developments, a finely produced new text-book of general pathology based mainly on Chinese material, and in Chinese, by Hu Chêng-Hsiang and others. Of course, the Peking University Medical College is not the only one in the capital; the Peking (now the Chinese) Union Medical College is also functioning intensively.

Both for research and teaching, Chinese scientific workers now have facilities incomparably greater than those which used to be available during the confusion and blockade of the Second World War. A great many instruments are now being made in the big cities such as Shanghai. In Academia Sinica laboratories, I saw excellent incubators and refrigerators, a variable-temperature insect-behaviour chamber, vacuum pumps, mechanical stirrers, shaking machines, ball mills and glassware, all made in China. A kind of 'Pyrex' ware is also locally available. Microtomes have been constructed by the Chinese Union Medical College workshops. At the Shenyang Medical School a consignment of two hundred teaching microscopes from East Germany had just come in during one of my visits, and my friends in the National Academy were making much use of East German catalogues. If normal conditions of trade can be restored, as all must hope, China would doubtless be glad to receive British scientific instruments. Heavier kinds of equipment are often Soviet in origin, and the Chinese are making excellent use of them.

Another emphasis which must be mentioned is that on popular education. There is a touching and genuine thirst for scientific knowledge among the Chinese people. Shops which sell anatomical models and geological charts have a crowd around the windows all day. If the visitor from the West wanders into one of the modern bookshops on a Sunday, he will almost have to step over rows of children and boys and girls of various ages sitting on the floor and against the bookcases reading popular science, and not paying the slightest attention to him. The assistants never insist on readers buying books, though they usually do, as they are relatively extremely cheap. I visited a popular exhibition of astronomy in the beautiful Pei Hai Park in Peking. It was packed with ordinary people, to say nothing of the usual large proportion of school-children, who were delighted with a simple form of planetarium. Most justifiably there were special panels accurately relating the ancient and medieval contributions of the Chinese to astronomy, such as the invention of the equatorial mounting by Kuo Shou-Ching in A.D. 1279; and the young man who was demonstrating these was delighted that a Western visitor was already familiar with these contributions and could even elaborate on them. Of great interest also was an exhibition of army education set up in the buildings surrounding the exquisite Temple of Heaven; here there were many pieces of simply constructed apparatus for demonstrating fundamental principles of physics, optics and the like; or, to take another example, out-patients passing through

the corridors at China Union Medical College would pause to look at illuminated model scenes inset into the walls, which explain the cycles of transmission of the chief helminthic infections known in the Chinese countryside. Will it not make some difference to the world that five hundred million people are awakening to the significance of natural science and all that that implies ?

Next, something may be said of a few of the researches which have been proceeding during the past three years. Stimulated by the importance of ethyl mercury chloride as a fungicide, the Institute of Physical Chemistry of the Academy has been studying the role of catalysts in the formation of this and similar compounds. The Institute of Organic Chemistry has been working on plant hormones and possible new antibiotics derived from certain plants traditionally used in Chinese medicine. From the point of view of economy it would obviously be of advantage to use as many of these as possible, and they are now undergoing more extensive study by modern methods than ever before; the China University Medical College, for example, has a special department for the investigation of Chinese materia medica. In physiology there has been work on micro-analysis of potassium, sodium and phosphorus in nerve tissue during activity. The Laboratory of Developmental Physiology has completed researches on the structure and mode of action of the eye-stalk hormone of Crustacea, and has isolated an active substance in the form of its cadmium complex. Systematic botany and zoology are being actively pursued by many workers; often in connexion with important practical problems, such as forestry, fisheries, and the epidemiology of rodent-borne plague. The palæontologists have been studying fossils of dinosaurs and their eggs at Laiyang in Shantung Province. They have also conducted large-scale excavations in the Choukoutien area near Peking in connexion with *Sinanthropus pekinensis*, the precious specimens of which were lost during the confusion of the Second World War, and are widely believed to be still in American hands. Palæobotanists have been concentrating on the mesozoic fossils of the Szechuan basin, and the redwood fossils in the coal beds of Fushun in southern Manchuria. Important work has been done by the Metallurgical Institute on new kinds of nodular graphite cast iron with superior strength and properties favourable to mechanical treatment. Its Kunming branch laboratory has been occupied with problems relating to the bauxite deposits of Yunnan province, and similar local needs. In so short a review as this it is, of course, impossible to do more than allude to a few of the subjects on which research is proceeding.

In conclusion, a few words may be said regarding the philosophical point of view of Chinese science to-day. In accordance with the world-outlook which has triumphed in China, Chinese scientists are greatly interested in dialectical materialism. The fact that there is very little opposition to it is noteworthy, and arises from several causes. There was never any strong strain of metaphysical idealism, such as that represented by Eddingtonian views, in Chinese thought. On the contrary, its finest formulation by the school of Chu Hsi in the Sung dynasty (twelfth century A.D.) was remarkably congruent with dialectical materialism, for this school worked with but two concepts: *ch'i*, matter, including its most tenuous forms, and *li*, the pattern or organization of things. These patterns were explicitly recognized to be arranged in levels of organization. For this world-picture dialectical materialism may readily be considered a continuation. In other words, the age-old and refined conceptions of Chinese humanism are fusing with dialectical materialism without that stress and strain felt in a Europe which has so long been the battlefield of irreconcilable opposites—either theological spiritualism, or atoms and the void.

OBITUARIES

Prof. F. E. Weiss, F.R.S.

The death of Frederick Ernest Weiss on January 7 at the age of eighty-seven severs one of our last direct links with the great men who, in late Victorian times, created the science of biology in Britain. The son of parents who were outstanding for their strength of character and high principles, he was born in Huddersfield on November 2, 1865. When he was seven years old his father died, and his mother with five young children moved, first to Heidelberg and later to Neuchâtel, to obtain a good education for her family.

Returning to England, Weiss entered University College, London, in 1884, with the object of taking a degree in botany; but in his first year he came under the spell of Ray Lancaster and devoted much of his time to zoology. He learned his botany from Prof. Daniel Oliver, D. H. Scott and, in his third year, from Prof. Frank Oliver, who had just come from Cambridge to succeed his father in the chair. After graduation, Weiss spent some time at Naples in research on *Amphioxus*, but returned to the study of botany as Quain student and lecturer in botany at University College. Three years later he was appointed professor of botany in Owens College, Manchester—now the University of Manchester—in succession to W. C. Williamson, the famous palæobotanist. Weiss held this chair until his retirement in 1930, and was responsible for the erection of new laboratories, and for the creation of a notable school of botanical study and research from which many well-known botanists originated.

Weiss followed his predecessor at Manchester in carrying on research on the structure of Carboniferous plants, especially on their root systems; but he also carried out investigations on pollination, seed dispersal, genetics and on graft hybrids. He took a keen interest in the study of vegetation, assisting in the work of the British Vegetation Committee and later in the foundation of the British Ecological Society, of which he was president during 1924–25. He devoted much of his time to the development of the botanical department of the Manchester Museum, and for many years gave a course of popular lectures in connexion with the Museum. His services to his University were considerable. Besides long periods of membership of its Council, he often acted as pro-vice-chancellor and served as vice-chancellor during two critical years, 1913–15. The appreciation of his work was shown by the award of the honorary degree of LL.D. He was a faithful supporter of the British Association, and was president of Section K (Botany) in 1911. He became a Fellow of the Royal Society in 1917, and served on its council.

After retiring from his chair at Manchester, Weiss moved to the neighbourhood of Guildford and spent much of his time at the garden of the Royal Horti-

cultural Society at Wisley, where he was chairman of the Scientific Committee. He was a member of the Council of the Society for two periods between 1935 and 1946 and served on its Library and its Scientific Committees, as well as on its Examinations Board. His service to horticulture was recognized by the award of the Victoria Medal of Honour in 1947. He also devoted much time to the Linnean Society, serving as its president during 1931–34. In 1937 he was president of the South Eastern Union of Scientific Societies.

Weiss was a man of exceptional charm and kindness, combining wisdom and experience with modesty and tact; he was loved and respected by all who had the privilege of knowing him. He had wide interests, not only in science and education, but also in social betterment and in the improvement of Manchester and its surroundings. He took and maintained an unfailing interest in the welfare of his students and younger colleagues; he was always ready to give them help and advice. In all his many interests and projects he was helped by his wife Evelyn, third daughter of the Right Hon. Dr. Robert Spence Watson, whom he married in 1898, and who, with their three daughters, survives him.

H. Hamshaw Thomas

Sir James French

We regret to record the death of Sir James Weir French, which occurred at his residence in Glasgow on January 14, at the age of seventy-six. James Weir French was born in Glasgow in April 1876 and was educated at Bearsden Academy and the University of Glasgow, where he graduated as B.Sc. in 1898; the degree of doctor of science was conferred on him some years later. While still at the University he entered the firm of Barr and Stroud and was appointed a director when the firm became a limited company in 1913. He was chairman of the firm from 1938 until he retired in 1949.

Sir James French had travelled widely and had gained considerable technical experience abroad. After the First World War, he was attached as an expert to the Inter-Allied Control Commission in Germany. He was knighted in 1941 in recognition of his contribution to the equipment of the Fighting Services.

Among important offices held by Sir James French in academic and scientific institutions and societies, he had been chairman of the governors of the Royal Technical College, Glasgow, president of the Royal Philosophical Society of Glasgow and lay chairman of the Glasgow Art Club.

Sir James's main energy was devoted to the design and development not only of the scientific instruments manufactured by Barr and Stroud, but also to the special optical machinery and materials necessary for their manufacture. During the First World War, when supplies of optical glass became critical, he was associated with the late Prof. Barr in the development and production of optical glass suitable for the highest standard of optical instruments. The subsequent large-scale production for the firm's instruments was largely due to his energy and initiative in devising the manufacturing processes and designing and constructing the necessary plant and equipment.

Sir James French published many scientific papers, chiefly on optical subjects; but his wide and detailed knowledge of the history of glass and porcelain, including those of ancient Egypt, made his papers on this subject of particularly wide interest.

Prof. J. S. S. Brame, C.B.E.

John Samuel Stafford Brame, who died on December 10 at the age of eight-one years, was an authority on fuels and lubricating oils. He was educated at St. Thomas Rich's School, Gloucester, and commenced his scientific studies and training at the Royal College of Science. In 1897 he joined the staff of the Royal Naval College, Greenwich, as an assistant to Prof. V. B. Lewis, who held the chair of chemistry. The latter so greatly influenced Brame that under his guidance he specialized in oil technology and combustion, especially that of oils in furnaces; Brame here laid the foundation for his life's work. This association with Prof. Lewis, a founder member of the Institute of Petroleum Technology, finally brought him to the highest position in this field, namely, president of the Institute.

When Prof. Lewis resigned from the chair of chemistry in the Royal Naval College in 1914, Brame was appointed as the first professor of chemistry and metallurgy, a position which he held until his retirement from the College in 1932. During the whole of this period he lectured upon petroleum in all its aspects, and carried out investigations connected with lubrication, combustion, etc. When it was proposed to use oil as a fuel for the Royal Navy, Prof. Brame took a keen interest in this proposition; he carried out experiments on the numerous oil-burning locomotives of the (then) Great Eastern Railway, and from this experience was able to indicate certain conditions for the burning of oil on ships.

On leaving the Royal Naval College, he was appointed a director of Messrs. Alexander Duckham and Co., Ltd., lubrication oil specialists, and held the position of technical adviser until 1939.

For many years Prof. Brame lectured at the Sir John Cass College, London, on oil technology. These lectures were considered a very important part of the educational system devised and financed by various oil companies for the training of their staffs.

During his activities at the Royal Naval College and at the Sir John Cass College, Prof. Brame held many important posts, including the chairmanship of the Standardization Committee of the Institute of Petroleum Technologists, a subject in which he was always interested. He was a Fellow of the Royal Institute of Chemistry, and of the Chemical Society. He was made a Commander of the Order of the British Empire in the New Year's Honours, 1930.

F. A. Ruddock

We regret to announce the following deaths:

Prof. Paul Niggli, professor of mineralogy and petrology in the University of Zurich and in the Swiss Federal Institute of Technology, Zurich, and also *correspondant* for the Mineralogical Section of the Paris Academy of Sciences, aged sixty-four.

Lieut.-Colonel J. S. Vorley, C.B.E., director of national parks, Southern Rhodesia, and formerly of the Indian Forest Service, on January 2, aged fifty-four.

NEWS and VIEWS

Institution of Electrical Engineers : Awards

Sir Harry Railing has been elected to honorary membership of the Institution of Electrical Engineers for his services to the electrical engineering profession and to the science, and for his services to the Institution. The Faraday Medal of the Institution has been awarded to Sir A. Stanley Angwin for his outstanding contributions to the development of telecommunications in Great Britain and in the international and inter-continental fields.

Sir Harry Railing

Born in 1878 and educated at the University of Munich, Sir Harry Railing received his early training and practical experience on the Continent of Europe and in the United States. In 1905 he went to the Witton Engineering Works of the General Electric Co., Ltd., to take charge of the test department and laboratories, and in 1911 he was made a director and placed in charge at Witton, where he remained for twenty years, a period of rapid expansion and development. In 1933 he left Witton for London, although he continued to control the organization of the Witton Works, and in 1941 was appointed joint general manager of the Company, becoming successively vice-chairman and then chairman and joint managing director. He was knighted in 1944. Sir Harry became a member of the Institution in 1912 and has held numerous offices, including the presidency (1944). He was also chairman of the Council of the British Electrical and Allied Manufacturers' Association during 1944–45 and was elected president last year.

Sir Stanley Angwin, K.B.E.

Sir Stanley Angwin was born at Penzance in 1883 and was educated at Queen Mary College, London. After being a pupil of Messrs. Yarrow and Co., engineers and shipbuilders, he joined the Post Office Engineering Department in 1906. During the First World War he served in the Middle East and France in the 52nd (Lowland) Divisional Signals and was awarded the M.C. and D.S.O. He then returned to the Post Office Engineering Department, joining the wireless section, which at that time was being expanded, and played a major part in the design and construction of the Leafield, Cairo and Rugby radio stations and in the inauguration of the trans-Atlantic telephone service. Sir Stanley became assistant engineer-in-chief of the Post Office in 1932, deputy engineer-in-chief three years later, and then engineer-in-chief during 1939–46. During the tenure of this last-named post, for the most part held during the stress of war, many significant technical developments took place, including the introduction and expansion of the short-wave overseas radio-telephone services which have given Great Britain so important a position in world telephony, and the adoption of the coaxial cable system as a normal method of providing trunk-line communications. Sir Stanley was knighted in 1941 and received the K.B.E. in 1945. He was president of the Institution of Electrical Engineers in 1943.

Experimental Physics in University College, Dublin: Prof. T. E. Nevin

Dr. T. E. Nevin, who has succeeded the late Prof. J. J. Nolan in the chair of experimental physics in University College, Dublin, graduated in the National University of Ireland in 1927. His first research was done on atmospheric electricity, under Prof. Nolan. In 1929, however, he was awarded an 1851 Exhibition, and during the tenure of this, under Prof. A. Fowler at the Imperial College of Science and Technology in London, and afterwards in Dublin, he has made many important analyses of band spectra. University College possesses a 21-ft. Rowland grating which has been used by him to unravel some very complex spectra, including negative bands of oxygen and bands of manganese hydride and deuteride. Prof. Nevin has also constructed a very large vacuum spectrograph, which is likely to come into use shortly. In recent years he has made experimental investigations of cosmic rays, in association with Prof. C. B. E. McCusker, of the Dublin Institute for Advanced Studies. Prof. Nevin has been a member of staff of the Physics Department of University College since 1931. He was elected to membership of the Royal Irish Academy in 1942, and has twice been a member of its Council. Since 1943, he has been a member of the governing board of various schools of the Institute for Advanced Studies, Dublin, and has delivered lectures on special topics under the auspices of the Institute.

Mathematics at the Royal Technical College, Glasgow : Dr. D. C. Pack

The governors of the Royal Technical College, Glasgow, have appointed Dr. Donald Cecil Pack, lecturer in mathematics in the University of Manchester, to the chair of mathematics in the College. Dr. Pack won an open scholarship in mathematics to New College, Oxford, and took his B.A. with first-class honours in mathematics in 1941. The degree of D.Sc., for a thesis on a subject in the field of compressible flow and shock waves, was conferred on him by the University of St. Andrews in 1951. In the Second World War he served with the Ordnance Board during 1941–43, working on ballistics and the trajectories of shells. Later, as a scientific officer with the Ministry of Supply, he was engaged in research on gas dynamics with particular reference to supersonic flow and the effect of shock waves. He was also concerned with researches on problems relating to the penetration of armour. When the War ended Dr. Pack spent some time on supersonic research at the German supersonic station at Völkenrode. He is the author of numerous publications in the field of gas dynamics, supersonic flow, propagation of shock waves and related problems. During 1947–51 he was a lecturer in mathematics in the University of St. Andrews, and during 1951–52 was a visiting research associate professor at the University of Maryland.

Atomic Energy for Industrial Power and other Uses

In reply to a question from Mr. Hector Hughes in the House of Commons on January 26, as to what progress had been made in British national research stations towards solving the problem of using atomic energy for industrial, travel and other peaceful purposes, the Minister of Supply, Mr. Duncan Sandys, said that the novel problems raised in the production of electrical power from atomic energy have been studied in the light of experience gained with the graphite piles at Harwell and at Windscale. Valuable discussions have also been had with Canadian experts about the results obtained in the operation of their heavy-water reactor at Chalk River, Ontario. The most certain method of generating power from atomic energy would be to build an improved type

of natural uranium reactor enclosed in a pressure shell, the heat produced being transferred by a gas under pressure through a heat-exchanger to a conventional electric-power generator. As a by-product, this would yield plutonium, which could be used as fuel for further reactors. The potentialities of such a reactor are being studied, and, if the prospects prove favourable, the construction of an experimental atomic-power station of this kind would be considered. At the same time, continued Mr. Sandys, it is hoped to develop reactors of a more advanced type, known as 'breeder-reactors' by reason of the fact that they are designed to produce more fissile material than they consume. To facilitate the study of these methods, a small experimental reactor of this kind is being built at Harwell. This should be completed in a few months time, and work is proceeding meanwhile at Harwell and Risley on the design and development of a full-scale breeder reactor, capable of producing substantial amounts of electricity. A suitable site for the construction of this plant is being sought.

A natural-uranium reactor moderated with heavy water is also being built, which will produce a much more intense flow of neutrons than is possible with the present equipment. This reactor is for research work and will not be used to generate power. It will, however, greatly expand the quantities and variety of radioactive isotopes which can be produced for industrial, scientific and medical purposes. This project will take about four years to complete. It is not proposed to undertake work on the application of nuclear energy to propulsion until more experience has been gained in the development of stationary nuclear power plants. Mr. Sandys pointed out that it is too early to say with any precision how soon electricity generated from atomic energy will be available on a significant scale for industrial purposes. Nuclear reactors will certainly not supersede existing methods of producing electric power in the near future; but if the technical problems are solved and the new methods prove to be economical, there is no reason why nuclear reactors should not, before very long, provide a useful additional source of industrial power.

Increased Expenditure for Research and Development by the Ministry of Supply

In presenting a Supplementary Estimate for the Ministry of Supply in the House of Commons on January 26, the Minister, Mr. Duncan Sandys, said that the need for the Estimate arises mainly from the increased rate of expenditure on research and development: expenditure for that purpose is expected to exceed by about £21 million the £128 million originally provided. Some of the increased expenditure is due to rises in prices and wages, but in the main it provides evidence that the progress of the technical and scientific establishments of the Ministry, and of the industries working with it, has been more rapid than was expected. A special effort has been made to accelerate the development of new types of air-frames, aero-engines, electronic equipment and improved methods of jet propulsion. Further encouraging progress has been achieved in work on guided rockets, and Mr. Sandys added that there is no doubt that the guided rocket is one of the decisive instruments and will come to dominate the military scene. To hold back our scientific workers or technicians in this vital field would, he said, be false and dangerous economy. The successful atom-bomb test at Monte Bello, continued Mr. Sandys, completed an important phase in our programme of atomic research and opens a wider horizon for further scientific activity. With the progress made in studying the peaceful applications of atomic energy, it justifies an expansion of our development programme in this field, and the unexpectedly rapid progress with processes of extracting uranium as a by-product from gold-mining in South Africa and the encouraging developments in uranium production in Australia have also increased expenditure on atomic energy. About £5 million out of a Supplementary Vote of £5·85 million under "Works Services" relates to research and development establishments and arises out of this programme.

In the debate on the Supplementary Estimate, numerous questions were pressed for further information, more particularly in regard to the expenditure on research. In his reply on the debate, the Parliamentary Secretary to the Ministry of Supply, Mr. A. R. W. Low, while declining to break down further the figures for the expenditure on research, particularly the £9·9 million under Subhead *B*3 for research and development work by industry, extra-mural research at universities and the like, agreed that the Vote would include some research work for civil purposes as well as some on atomic energy. He said that he is satisfied that, where there are overlapping problems, there is consultation with all those concerned. No answer was given to Mr. Emrys Hughes's request for a clearer indication as to what is understood by research, or to Mr. F. Lee's inquiries as to the steps taken to facilitate the application to industry of the results of research at the earliest possible moment or as to the numbers of scientific workers and technologists engaged in research and the capacity of the universities to supply them.

National Institute of Sciences of India: Presidential Address, 1952

In his presidential address to the National Institute of Sciences of India, given on October 4, 1952, at the Museum House, Calcutta 13, Dr. Sunder Lal Hora dwelt on a number of topics pertaining to science in India. He first mentioned his pleasure that the three scientific Surveys of India—Geological, Zoological and Botanical—should recently have been grouped under one Ministry, that of National Resources and Scientific Research; also to this Ministry there now falls the care of the seven administrative units of the Indian Museum. Turning to the Institute itself, Dr. Hora discussed the publishing of original papers in the Institute's *Proceedings*, forty-four of the fifty-six submitted during 1951 having been published. The delay at present is seven to nine months, but by various means, including the printing of routine business in a new regular journal, the *Bulletin*, and in the Institute's "Year Book", it is hoped to find more space in the *Proceedings* for original work and at the same time to reduce the delay to not more than six months. As regards the quality of the English in the papers submitted, Dr. Hora pointed out that the standard is noticeably deteriorating, and he suggested that this fact should be borne in mind by the Government when formulating any plans about the place of the English language in its educational curricula. Dr. Hora did not flinch from making other critical comments. Thus, he said that he was disturbed at the apathy shown towards the activities of the Institute, even by its Fellows, and he went on to

indicate that this is but one facet of a general failure by Indians to appreciate the merits of their country's scientists, as shown by the relatively poor salaries paid to those working in academic circles and also by the tendency to employ foreign scientific advisers in preference to local talent. In conclusion, Dr. Hora discussed the stepping-up of the biological sciences in India, and in this connexion the Institute has decided to recommend that departments for the special study of certain subjects should be established as follows: a marine biological station at Bombay; a central freshwater biological station at Mettur, Madras State; animal genetics at a cancer research centre in Bombay, a cytogenetics research wing at the University of Calcutta and a cytochemistry research wing at the University of Mysore; and plant genetics at the Indian Agricultural Research Institute, Delhi.

Electron Microscopy of Plant Cilia

FURTHER observations on the structure of plant cilia, by a combination of visual and electron microscopy, are given by I. Manton, B. Clarke, A. D. Greenwood and E. A. Flint in the current issue of the *Journal of Experimental Botany* (3, No. 8, 204; 1952). The cilia of zoospores of *Saprolegnia ferax*, *Chlorosaccus ulvaceus*, *Allomyces arbuscula* and *Olpidium brassicæ* are illustrated by some excellent photographs at magnifications ranging from × 2,000 (visual light under an oil immersion objective) to × 20,000 (electron micrograph). The flagella of these micro-organisms (three fungi and a yellow-green alga) showed eleven component strands, these usually being clearly differentiated into a central pair and nine others. These strands are observable in specimens which are undergoing fibrillar disintegration. Similar strand numbers have also been observed in ferns and in green and brown algæ. Stained and unstained specimens of *Saprolegnia* and *Chlorosaccus* have been closely compared in the electron microscope and the nature of the artefacts produced by staining investigated. Visual and electron micrograph records of one and the same stained cell have also been compared. Observation of the very distinctive but closely comparable flagellar character in brown algæ, yellow-green algæ and certain fungal and flagellate groups has led the authors to the conclusion that these groups are phyletically more nearly related to each other than they are to other groups, for example, green algæ (see also p. 280 of this issue of *Nature*).

General Principles of University Research

IN *Research for Industry* (4, No. 5; July 1952), the news bulletin of Stanford Research Institute, Dean Ernest R. Hilgard, of the Graduate Division of Stanford University, writing on "Fundamental and Applied Research in relation to the University", lays down three criteria for the choice of possible research projects by a university, including research grants or contracts offered by industry or government. First, the project should be in line with the professor's special interest and training; second, it should preferably be of a kind to make good use of the students and to provide them with a rounded training in research; third, it should normally lead to scholarly publication. These criteria do not exclude applied research, since it can meet these standards provided the inquiries are conducted in the true scientific spirit. Examining the kinds of research which normally should be less favoured by a university, Dean Hilgard lays down four further criteria. First, projects serving the immediate aims of industry or government but lying outside the scholarly interests of the staff and not in the direction of intended development; second, those requiring a pace of development best served by non-teaching scientists and full-time technicians; third, specialized projects requiring a staff so large as to disturb the equilibrium of the university; and fourth, research which requires excessive travel away from the university.

Latin-American Course in São Paulo on Radioisotope Methodology

A COURSE on radioisotope methodology, the first of its kind ever to be held in Latin America, has been organized by the Faculty of Medicine of the University of São Paulo, Brazil, under the direction of Prof. A. Wormall, who has been temporarily seconded from the Department of Biochemistry and Chemistry, St. Bartholomew's Hospital Medical College, London, assisted by Dr. Tede Eston, Dr. Veronica Rapp de Eston, Prof. P. B. Smith and Miss Constancia Pagano, of São Paulo. The course, which started on January 14 and is a full-time one, lasting for six weeks, consists of two whole days of practical work each week together with theoretical lectures on the experiments to be made; in addition, four theoretical lectures are being given weekly and seminars held in connexion with the laboratory work. Those taking the course are graduates in science or medicine, and thirty men and women are at present participating, nineteen being from Brazil and eleven being holders of Unesco fellowships from other Latin-American countries; the limitation in numbers is due to the difficulties of accommodating the practical work, but there is no restriction on the numbers who may attend the lectures, and, in fact, four others are doing so. Most of the participants hold responsible positions in universities, research institutions or hospitals, and it is hoped that the course will enable them to make profitable use of radioactive isotopes for research and for clinical medicine. Further details can be obtained from the Laboratório de Isótopos, Faculdade de Medicina, Caixa Postal 2921, São Paulo, or the Divisão de Difusão Cultural, Reitoria da Universidade de São Paulo, rua Helvetia 49 a 55, São Paulo.

Physical Society's Annual Exhibition

THE thirty-seventh annual exhibition of scientific instruments and apparatus arranged by the Physical Society will be held during April 13–17 in the Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7. A return has been made to the practice of former years of placing the whole of the exhibition in the main buildings of the College (except for one heavy exhibit housed in the Mathematics Department of the Huxley Building, Exhibition Road, for which tickets of entry will not be required). Three discourses, each lasting approximately forty-five minutes, will be given at 6.45 p.m. in the Large Chemistry Lecture Theatre as follows: April 14, Dr. E. C. Bullard (National Physical Laboratory), "Seismic Study of Ocean Basins"; April 15, Dr. L. A. Jordan (Paint Research Station), "Particles, Pellicles; Pigments, Paints and Physics"; April 16, Prof. W. V. Mayneord (Department of Physics, Royal Cancer Hospital), "Scintillation Counting and its Medical Applications". A handbook giving details of the exhibits will be published early in March and will be available at the exhibition or ordered from the Physical Society (price 6*s*., or

7s. 3d. by post). The exhibition will be open at the following times: April 13, 10.30 a.m.–8 p.m. (Fellows and Press only, 10.30 a.m.–2 p.m.); April 14–16, 10 a.m.–8 p.m.; April 17, 10 a.m.–5 p.m. Application for tickets, which are of various types, available for part or all of these times, should be made as soon as possible to the Exhibition Secretary, Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7, from whom all further particulars can be obtained.

Electronic Instruments in Atomic Energy: Course at Harwell

A SPECIALIZED course on the design, use and maintenance of electronic instruments used in nuclear physics, radiochemistry and in work with radio-isotopes will be held at the Isotope School of the Atomic Energy Research Establishment, Harwell, during March 16–20. The course will be limited to twelve people who are physicists or electronic engineers holding a degree or equivalent qualification, and will include lectures and practical work on counters, D.C. and pulse amplifiers, coincidence units, scalers and rate-meters. The instructional staff will be drawn from the Atomic Energy Research Establishment, but the Isotope School is outside the security fence and the subject-matter will be entirely unclassified. The fee for the course is 12 guineas, and living accommodation (at Buckland House, near Faringdon, which is one of the senior staff hostels of the Establishment), transport and morning and evening meals will be provided at a charge of 7 guineas. Application forms can be obtained from the Electronics Division, A.E.R.E., Harwell, near Didcot, Berks.

Royal Society Lectures for 1953

ROYAL Society Lectures for 1953 will be delivered as follows: Croonian Lecture, on June 11, by Sir Ronald Fisher, professor of genetics, University of Cambridge; Bakerian Lecture, on May 7, by Prof. N. F. Mott, professor of physics and director of H. H. Wills Physics Laboratory, University of Bristol; Ferrier Lecture, on December 10, by Dr. F. M. R. Walshe, consulting physician to University College Hospital and to the National Hospital for Nervous Diseases; Wilkins Lecture, on March 5, by Sir Harold Hartley; Leeuwenhoek Lecture, on November 5, by Dr. K. M. Smith, director of the Plant Virus Research Unit (Agricultural Research Council), Molteno Institute, University of Cambridge.

Announcements

THE Council of the Royal Society has appointed Sir James Chadwick as the Rutherford Lecturer for 1953; he will deliver the Lecture at McGill University, Montreal, in the autumn. This is the second Rutherford Lecture to be given under the terms of the Rutherford Memorial Fund, the first having been delivered last year in New Zealand by Sir John Cockcroft.

THE Guthrie Lecture of the Physical Society, which is given annually in memory of the founder of the Society, will be delivered on March 13 in the Lecture Theatre of the Science Museum, Exhibition Road, London, S.W.7, at 5 p.m., by Prof. M. Born, who will speak on "The Conceptual Situation in Physics and its Prospects of Development".

A CENTENARY Lecture of the Chemical Society will be given by Prof. A. Tiselius, of Uppsala University, at 7.30 p.m. on February 26 in the Lecture Theatre of the Royal Institution, Albemarle Street, London, W.1. The subject of the Lecture will be "Some Applications of the Separation of Large Molecules and Colloidal Particles".

A CENTENARY EXHIBITION of prints from the Royal Photographic Society's Permanent Collection and photographic apparatus collected by the Society and the Science Museum has been arranged at the Science Museum, Exhibition Road, London, S.W.7, and in the Society's House, at 16 Princes Gate, London, S.W.7. The Exhibition will be open from February 17 until March 28.

AT the general monthly meeting of the members of the Royal Institution, held on February 2, Mr. Stanley Robson was elected secretary to fill the vacancy caused by the resignation of Prof. A. O. Rankine.

MR. A. B. DUNCAN, chairman of the finance committee and a member of the Scottish committee of the Nature Conservancy, has been appointed chairman of the Conservancy in succession to Sir Arthur Tansley.

MR. M. W. THRING has been appointed an assistant director of research of the British Iron and Steel Research Association. He will continue as head of the Physics Department of the Association.

MR. F. E. BRUCE has been appointed to the University readership in public health engineering tenable at the Imperial College of Science and Technology, London. The degree of *D.Sc.* (Engineering) of the University of London has been conferred on Mr. Stanley Whitehead.

THE third annual conference of the Ergonomics Research Society will be held in the Department of Human Anatomy, University of Oxford, during April 13–16, and will take the form of a symposium on "Human Performance: its Measurements and Limitations". The conference will be under the chairmanship of Prof. W. E. Le Gros Clark. A fee of 30s. is charged for those who are not members of the Society. Limited accommodation is available in Brasenose College. Enrolment forms (to be completed at the latest by March 31) and further information can be obtained from H. Murrell, Spinneys, Marlpit Lane, Headless Cross, near Redditch, Worcs.

A conference marking the twenty-fifth anniversary of the Sub-Committee on Dust Technology of the Verein Deutscher Ingenieure will be held in Essen during March 26–27. After an introduction by the chairman, Robert Meldau, a number of papers will be read, including one by Prof. P. Jordan (University of Hamburg) on the distribution of fine dust in new theories on world creation, another by Prof. Correns (University of Göttingen) on dust in the formation of sedimentary rocks, and seven other papers dealing with various aspects of dust technology.

THE first Marjory Stephenson Memorial Lecture will be given by Dr. D. D. Woods at the Royal Institution, Albemarle Street, London, at 6 p.m. on April 13, his subject being "The Integration of Research on the Nutrition and Metabolism of Micro-organisms". The Lecture is open to the public. The Marjory Stephenson Memorial Fund is administered by the Society for General Microbiology, and the Lecture will be given during the sixteenth general meeting of the Society. Further details can be obtained from the general secretary of the Society, Dr. J. G. Davis, 52 London Road, Reading, Berks.

HYDROBIOLOGY AND INLAND FISHERIES OF AFRICA

THE principle of the symposium as a means of taking stock and stimulating new work in science may be said to have a value which is in direct proportion to the isolation of the workers concerned. Thus symposia have special value in the more remote parts of the world where many workers are to-day striving towards common objectives in small institutes or organizations hundreds or even thousands of miles apart. A good example was the symposium on African hydrobiology and inland fisheries which was held during October 14–17, 1952, under the ægis of the Scientific Council for Africa South of the Sahara. It brought together more than forty workers in these subjects from sixteen different territories in Africa, including Belgian, French, Portuguese and British Colonies, the Union of South Africa and Southern Rhodesia. The site was Entebbe in Uganda, appropriate in that it is near the centre of Africa and is lapped on three sides by Africa's largest lake.

The symposium was opened by Sir Andrew Cohen, Governor of Uganda, in an erudite speech in French and English. He mentioned the progress in African scientific co-operation which is being achieved by the Commission for Technical Co-operation in Africa and by the Scientific Council for Africa South of the Sahara, and pointed to the importance of the development of fisheries in solving a major nutritional problem of Africa, particularly in a country like Uganda, which has more than its fair share of lakes and swamps. He referred particularly to the need for scientific background: "It is a commonplace," he said, "so great that it need not be repeated publicly, that one of the main keys to agricultural development lies in the knowledge of soils. In the development of fisheries the water is the soil, and yet we know too little about our waters".

The contributions and discussions inevitably covered a wide range, including comparison of the organizations in the various territories, information services, fish and fisheries of natural waters, fish farming, trout fisheries, hydrobiology in relation to disease, legislation, and the co-ordination of fishery interests with those of agriculture and other subjects in the use of Africa's meagre water supplies. From the Belgian Congo, C. Halain described the successful results of the campaign for establishing numerous fish farms in native areas, and Dr. A. F. de Bont described scientific results achieved in that connexion, these being compared with experience in fish farming contributed by Dr. D. Hey and Dr. S. S. du Plessis from South Africa, J. L. Lemasson and others from the French territories, H. C. Copley and Dr. V. van Someren from Kenya, O. E. Symes from Nigeria, and others. The fish farming industry of Africa is being built mainly on the numerous local species of *Tilapia*, and this led to discussion on the transportation of fish from one drainage basin or fish region to another. It was generally agreed that, while economic development cannot be held up, it is more important during the next few years to learn more about the local endemic species in their natural waters and under conditions of culture, than to distribute widely those few species which have already proved themselves useful under domestication.

Sessions devoted to natural waters included some important contributions on production biology from the East African Fishery Research Organization's laboratory at Jinja, which has now been in existence for several years. R. S. A. Beauchamp and G. R. Fish, for example, threw considerable light on the highly complex hydrology of Lake Victoria. Dr. J. Rzoska, from the University College of the Sudan, described hydrobiological researches on the White Nile, particularly the influence of the reservoir contained by the Gebel Aulyia barrage near Khartoum.

An academic note was sounded in discussions of the ecology of tropical swamps introduced by Prof. L. C. Beadle, of Makerere College, and on the biology of speciation in African lakes introduced by Dr. E. B. Worthington. This turned around the debatable problem of sympatric and allopatric speciation, which was argued particularly, by P. H. Greenwood from his studies of *Haplochromis* flocks in Lake Victoria, Miss R. Lowe on the associations of *Tilapia* species from Lake Nyasa and elsewhere, and Dr. G. S. Carter, who is spending a year at the Jinja Laboratory on sabbatical leave from Cambridge.

Much new information was brought to light on a variety of African fishes in relation to their environments, particularly those of economic importance and including the introduced species of trout in the highland areas. A feature of the meeting was an account of research on fish-eating birds and on the ecology and economic status of the crocodile by another visiting worker from Cambridge, Dr. H. B. Cott. His results promoted discussion on the policy which should be adopted by Governments in applying some control to the industry in crocodile skins, which in some waters may threaten the very existence of crocodiles. Whereas views were expressed that the crocodile is an animal which could well be dispensed with in areas of economic fisheries, particularly on account of the destruction which it causes to fishing nets, it was generally admitted that its influence on food chains is yet inadequately known and might sometimes be beneficial. For example, an experience was recounted from Madagascar that the destruction of crocodiles had been associated with an increase in the incidence of rabies: crocodiles no longer eliminated rabid dogs which were drinking.

Prof. J. Millot (of the Muséum d'Histoire Naturelle, Paris, and of Madagascar), who was chairman of the symposium, remarked in his concluding speech that the meeting as a whole had provided the opportunity for a thoroughly useful exchange of experience and views from a very wide region, and the contributions and discussions had achieved a high scientific standard. The fact that the hydrobiology of Africa is achieving a considerable importance and is less isolated than formerly is illustrated by the fact that no less than ten of the participants at this symposium expect to attend the Twelfth International Limnological Congress, to be opened during August at Cambridge. The language problem, which is so apt to impede international meetings, was solved by simultaneous interpretation at the symposium. A full record will appear as an official publication in due course. E. B. WORTHINGTON

SIGNIFICANCE OF RACIAL DIFFERENCES

DR. G. M. MORANT'S informed and clearly reasoned pamphlet on "The Significance of Racial Differences"* makes an important contribution to the series of publications on the question of race published by the United Nations Educational, Scientific and Cultural Organization. Racial differences, their extent and their significance, are burning questions to-day when racial stresses are rampant. What has been established by a century of scientific inquiry should be more widely known, and the methods of approach to such questions more widely understood. "Popular views of the matter are still nebulous enough to be swayed by anyone who chooses, for his own ends, to spread 'racial' dogmas which cannot readily be proved true or false."

Racial differences, physical and mental, have indeed been a subject for literary discussion for two thousand years and more. But a fundamental weakness is that it has no agreed systematic method of considering such questions of group difference. The classes of evidence chosen for emphasis and the choice and interpretation of items in those classes are usually such as best fit some general theory of the writer's; they offer a wide field for bias and produce many contradictory conclusions. But certain tendencies are general: to regard as 'racial' many differences that are environmental or cultural; to reduce, for simpler thinking, the variety that every group exhibits to the uniformity of a single type; to endow that type with the more extreme and striking attributes of a few, rather than with those of the group as a whole; and to assume that groups which are markedly different in regard to some obvious physical attribute must have certain marked differences in mental make-up.

Scientific inquiry, on the other hand, whether into the physical, physiological or mental constitution of human groups, has the same agreed basic method of approach, which the author describes. By techniques of analysis which compare groups as a whole, it has established for many attributes (or 'characters'), especially physical, the actual extent of racial differences. "The ways in which men differ are of small account compared with the ways in which they are alike, but the former make up the class defining individual and group distinctions."

Though the physical differences between groups may often have little practical importance—apart from the influence on attitudes and intercourse of any that make very obvious distinctions between peoples—the results of the study of the physical characters have this advantage: that most characters of form, size or colour are mainly (and blood groups are believed to be entirely) determined by hereditary factors; whereas the outward manifestations of mental characters are determined to a considerable extent by experience and social environment. In both cases it is the hereditary, the racial, factors that are in question, and the ampler findings in regard to physical characters can throw light on the more complex question of the mental differences between racial groups.

Within all racial groups for which there are adequate records over the past seven thousand years, physical variation as recorded is of much the same order: rather less, as a rule, in the earlier series than the later, but not much; rather more in modern Europe than elsewhere, but with exceptions. There is considerable variation in group averages; but for very few 'continuous variables', apart from characters of colour and hair form, can groups be found the distributions of which do not overlap. Even in stature, and taking groups at opposite ends of the range, the tallest Congo pygmy is about as tall as the shortest Dinka; and in pairs of racial series selected at random about one in three would differ in average height by less than 4 cm. Dr. Morant, by a slip, says "about one in 130" (p. 32), a figure contradicted by the evidence of his distributions; also, in stating (p. 41) that no other measurement is known to differentiate racial populations as effectively as stature and cephalic index, he overlooks nose-breadth, which differentiates more effectively than either—hand-breadth probably too (*Man*, 50, No. 14). These errors do nothing to weaken his argument. For almost all metric characters, inter-racial variation is less than intra-racial, and the distributions for even the most divergent groups overlap widely, so that a large proportion of the individuals belonging to one could belong to either.

Valid comparisons between group averages for innate, hereditary, mental ability and disposition are difficult to make for racial groups whose mental experience is very different; but mental tests have at least shown a wide range of variation in any group tested, and—allowing for differences of background—wide overlap in group distributions. A rule found to apply to all forms of life is that variation within inter-breeding groups is associated with variation between such groups; and it is improbable that man's mental characters, unlike his physical, are an exception. "The general inference is that there are racial differences in mentality, although clear demonstration of them—regarding particular characters and particular pairs of populations—is not available yet". The differences are not likely to be all in favour of the same groups. Nor does it necessarily follow that a wide average difference in some physical trait is associated with a wide average difference in some mental trait. Also, the average mental differences may be small: existing evidence suggests "that group diversity tends to be less in degree for mental tests than for body measurements"—if less, not less significant.

Dr. Morant points out an aspect of group difference that, for mental characters, may make a distinction of importance. Two overlapping distributions of which the mean values are not far apart are yet likely to differ considerably in their relative frequencies of individuals having extreme values of the character. "There may be almost equal proportions of stupid, mediocre and able people in two populations; even so, exceptional ability may be found with a frequency of 1 in 1,000 in one group and with a frequency of 1 in 10,000 in the other. Having a larger proportion of exceptionally able members may be a factor which tells decisively in favour of a population in the course of centuries or milleniums." One might go further than does Dr. Morant in this informative and thoughtful pamphlet: at turning points in a nation's history it may tell decisively, though briefly, on its whole future course.

M. L. TILDESLEY

* "The Significance of Racial Differences". (The Race Question in Modern Science.) By Dr. G. M. Morant. Pp. 48. (Paris: Unesco; London: H.M.S.O., 1952.) 1*s.* 6*d.*; 25 cents; 75 francs.

NEW ZEALAND FOREST SERVICE

REPORT FOR THE YEAR 1950–51

THERE is a breezy directness about the annual forestry reports of New Zealand* which should invite public attention. Yet under the heading "Purpose of Annual Report", the Director of Forestry writes: "Practically without exception the annual reports of the Director of Forestry have been used consistently since 1934 to review forest policy. There have been few if any facets of policy that have not been reviewed on numerous occasions. Primarily, these reviews have been intended to inform Parliament on the Department's discharge of its responsibilities under the various Forest Acts and their amendments. Equally, they have been directed at the public in the expectation that, the annual reports being public documents freely available both to the press and to interested bodies, the public would be adequately informed of the evolution of forest policy. That expectation has proved illusory. A month seldom passes without there being some definite evidence that policy reviews are either not consulted or completely ignored. Clearly, annual reports are insufficient in themselves to promulgate forest policy". In forestry matters the Director is not alone in this discovery.

One of the chief troubles in New Zealand, as elsewhere in both the Old and New Worlds, is fire damage. The Director contrasts New Zealand with Scandinavia where, he says, fire protection work is much less costly because the people have become forest-minded. This is true of the peoples of other parts of Western Europe, and we have yet to acquire this attribute in Great Britain. In New Zealand, on the other hand, says the report, there is a tradition of land-clearing to make farms, and most of the people of the cities are out of touch with forests and forestry. In order to improve fire publicity, the campaign against fire is now to be merged in public relations affairs.

In the annual report for 1948–49, under forest policy, it was announced that the decision had been taken by the Government to establish a saw mill and a pulp and paper mill at Murupara on the Rangitaiki River in the Rotorua Forest Conservancy —the first of its type in the Dominion (see *Nature*, 165, 966; 1950). There was afterwards considerable hesitancy in embarking on this great scheme to exploit the extensive forest in question. The proposed development is of high interest in its novel departure. Later in the year the Government finally took the momentous decision to proceed with the project, and in order that the resources of this great forest may be exploited without further delay, the Government effected, during the 1950 session, the passage of legislation empowering the construction of the Edgecombe–Murupara Railway and granted financial authority for the work.

On the subject of soil conservation, about which so much is talked and written nowadays, the report correctly says: "The joining of soil conservation with river control has served to cloud the fundamental issue that in the final analysis both soil and water problems are essentially land and not engineering problems". The example is given of the failure of the British groundnuts scheme, and allusion is made to serious fears that all is not well with the much-advertised Tennessee Valley Authority scheme. As is well known, the necessary protection of the headwaters of the various waters upon which the scheme is based was ignored.

It is estimated that 80 per cent of the erosion and flooding troubles of New Zealand would ultimately disappear if land and forest fires could be entirely eliminated; a further 15 per cent would be rectified if overgrazing by wild life and by farm animals could be stopped, and other better farming practices universally instituted.

E. P. STEBBING

* New Zealand State Forest Service: Annual Report of the Director of Forestry for the Year ending 31st March 1951. Pp. 79. (Wellington: Govt. Printer, 1951.) 1s. 6d.

METEOROLOGICAL OFFICE

REPORT FOR THE YEAR 1951–52

THE principal feature of the report of the Director of the Meteorological Office for the year ending March 31, 1952*, is the attention which is being devoted to the study of the atmosphere in the region between about 30,000 and 50,000 ft. in height—roughly the top of the troposphere and the lowest part of the stratosphere. This region is particularly important because jet aircraft fly in it at a fuel consumption which for the distance covered is less than at lower levels. The winds there are sometimes very strong, having been known to exceed 150 knots (about 280 km./hr.), and the air is sometimes bumpy for no visible cause (such as thunderclouds) which would give warning to pilots. The forecasting of wind-speed and -direction and turbulence in this region is an important meteorological problem. The increased attention given to the upper atmosphere is partly shown by the formation during the year of a new Branch of the Office for detailed study of the Climatology of the Upper Air; previously, this work had been the function of a section of the Overseas Climatology Branch. Research into the forecasting of winds at high levels has continued during the year, and analysis of occasions of clear-air turbulence has confirmed earlier indications of an association between turbulence and the presence of marked variation in wind-speed in the vertical and horizontal directions. The work on turbulence included observations by the Meteorological Research Flight of the behaviour of smoke trails emitted by aircraft.

The forecasting of radiation fog is a major meteorological problem of importance to all forms of transport. A special organization was set up at Cardington (Bedford) to examine the development of fog. The work includes observations with the aid of instruments which can be carried by kite-balloon to more than 2,000 ft. Experimental forecasts for four days ahead were prepared twice weekly in the Forecast Research Division. A measure of success was attained; but the reliability of the forecasts was not sufficient to enable a decision to be made to devote additional staff to this work. Among other subjects of research described in the report are the study of cloud structure by radar, icing on aircraft, and the development of instruments, such as the radar theodolite, for measuring upper winds.

The meteorological services provided for the Royal Air Force and Army, civil aviation, the general public and industry continued to expand. A large meteorological exhibition was set up in the Dome of Discovery of the Festival of Britain Exhibition in

* Annual Report of the Director of the Meteorological Office presented by the Meteorological Committee to the Secretary of State for Air for the Year April 1, 1951, to March 31, 1952. (M.O. 562.) Pp. 56. (London: H.M.S.O., 1952.) 2s. net.

London. The exhibition included a weather-forecasting unit at which a special souvenir weather report and forecast was compiled, and more than 150,000 copies were sold to visitors. The overall strength of the Office staff decreased from 2,601 to 2,589 during the year; but the scientific officer class increased from 160 to 165. A number of university students, mainly of physics and mathematics, worked in the research centres of the Office during vacations.

DRYING OF HIDES AND SKINS

IT is twenty years since experimental work in Kenya yielded results which established principles for the correct drying of hides; the experience gained since that time has now been described by J. R. Furlong, principal of the Colonial Products Advisory Bureau (Plant and Animal) (*Colonial Plant and Animal Products*, 2, No. 4; 1951).

To obtain the best possible leather from a hide, it is desirable to proceed to the tanning operations without reducing the hide to a dry state. Many countries, however, have insufficient native hides for their needs, and it is necessary to bring supplies from overseas or long distances to the tanneries. The distance which green or lightly salted hides can safely travel without damage caused by putrefaction is very limited, and it is essential to submit the hides to some process of curing in order that they may be transported and stored without deterioration. The curing may consist of salting the hide and transporting it in a wet-salted condition—an expensive method applicable to the best qualities of hides, or the material, after salting, may be dried out and sent to the market in a dry-salted condition. In many countries, however, salt is scarce and the use of the imported material would be too costly. Recourse is therefore made to the procedure of air-drying as a method of preservation. This is practised in many hot countries, particularly in the African continent. Dry hides represent a large proportion of the production of the entire output of such countries as Nigeria, East Africa, South Africa, the Sudan and Abyssinia, while India and South America are also large producers of dry hides.

Dry hides are an important class of raw material for the tanneries of the world to-day. In the decade before the War many tanners had developed a technique for producing leather of the highest quality from this class of hides, and during the War a still larger number of tanners in the United Kingdom were forced to use Colonial dry hides for the first time. While Continental tanneries had always handled Colonial hides, it is the great advance which has been made in this connexion in the United Kingdom, as a result of war-time experience, that is of significance. Tanners have learnt how to obtain good results, and it is to Colonial sources that English tanneries now look for increasing supplies of their raw materials.

The article describes methods which are now being used in the suspension-drying of cattle, goat and sheep skins, and emphasizes that the old method of drying hides and skins on the ground is liable to cause serious damage, and should never be employed. Drying hides and skins on the ground should be prohibited in areas where the improved processes of suspension-drying are practicable.

HANDLING OF RADIOACTIVE AND TOXIC SUBSTANCES

AN edited report of the proceedings of the symposium on the handling of radioactive and toxic substances, which was organized by the Chemistry Division of the Atomic Energy Research Establishment, Harwell, and which was held in two sessions on September 10–11 and 13–14, 1951, at Buckland House, near Faringdon, Berks, has recently been issued*. Sixty-four representatives from the chemical industry, universities, hospitals, government research establishments and the atomic energy projects of Western European countries attended. A list of the various representatives and their respective organizations is included in the report. The chairman, Dr. R. Hurst, welcomed the representatives, and mentioned that the original suggestion to hold such a symposium came from Dr. R. Spence, the head of the Chemistry Division at Harwell.

The contributed papers and subsequent discussion centred around three topics: the use of glove boxes, remote control of chemical operations and laboratory housekeeping and decontamination. Dr. Hurst, who spoke first, described the various improvements and requirements in the design of glove boxes which experience of their use at Harwell has indicated. He stated that glove boxes provide the simplest means of confining a chemical operation so as to prevent the spread of radioactivity, or to exclude oxygen, dust or harmful organisms. Suitable gloves developed for use in these boxes were described and shown. The use of heat-sealed polyvinylchloride bags for the transfer of active material or apparatus into or out of glove boxes was recommended. Mr. J. G. Bell then gave details of a glove box design with double-wall protection for work on alpha-active materials which require a protective atmosphere, and Mr. W. G. Busbridge discussed the requirements of filters for use with glove boxes. The disadvantages of wool-resin filters were pointed out, and a new type of filter employing a mechanical filter of wool and asbestos was briefly described.

On the subject of remote control of chemical operations, the discussion centred on two general methods: systems of tongs, manipulators and periscopes, by which conventional apparatus can be used by an extension of the hands; and systems by which liquids can be transferred, precipitates removed and similar operations conducted by vacuum-lifting or by pumping from vessel to vessel. In this section papers were read by J. Dean and A. B. Ritchie, G. B. Cook, G. N. Walton, G. Wortley, and Dr. W. J. Arrol. Finally, Dr. G. L. Miles reviewed the general problem of laboratory management in radiochemical work, the housekeeping techniques which are essential to prevent and restrict the spread of radioactivity and to keep the working-space clean and free from contamination. It was emphasized that hoods, glove boxes and apparatus should have hard smooth surfaces, that detergents are generally satisfactory as decontaminants and that certain radioisotopes may need special treatment. Recommendations on the disposal of active waste were also made.

The report makes interesting reading and is amply illustrated by photographs and diagrams.

* Atomic Energy Research Establishment. Symposium on the Handling of Radioactive and Toxic Substances, held in Two Sessions on September 10–11 and September 13–14, 1951, at Buckland House, near Faringdon, Berkshire. (A.E.R.E., *C/R* 958.) Edited by G. R. Hall. Pp. iv+37+31 pl. (London: H.M.S.O., 1952.) 12*s.* 6*d.* net

HISTOCHEMISTRY OF SUCCINIC DEHYDROGENASE

By Dr. H. A. MALATY and Dr. G. H. BOURNE
Department of Histology, London Hospital Medical College, London, E.1

KUHN and Jerchel[1] synthesized various substituted tetrazolium salts and showed that their aqueous solutions stained living tissues (for example, yeast and bacteria). Various other workers confirmed this (see Smith, ref. 2). Tetrazolium is a compound which becomes coloured when it is reduced, and this suggested that the effect of its solutions in colouring living tissues may be due to the effect of reducing substances or to dehydrogenases present in them. Jerchel and Kohle[3] showed that it was possible for these tetrazolium compounds to act as hydrogen acceptors for some pyridine-nucleotide dehydrogenases. Tynen and Underhill[4] first used tetrazolium (triphenyl tetrazolium chloride) as a histological reagent, demonstrating subcutaneous fat with it. They found that injection of a 1 per cent aqueous solution of triphenyl tetrazolium chloride into mice stained neutral fat a bright orange-red in 5–10 min. They suggested that the fatty tissue caused reduction of the tetrazolium to a formazan pigment. Black and Kleiner[5] also used the same compound for measuring the respiration of tissue slices, and Kun and Abood[6] appear to have been the first to use it specifically for the estimation of succinic dehydrogenase activity.

Rutenberg, Gofstein and Seligman[7] described the synthesis of blue tetrazolium and its use for estimating succinic dehydrogenase activity in tissue homogenates. Afterwards, Seligman and Rutenberg[8] showed that this enzyme could be demonstrated histochemically using blue tetrazolium. An analysis of the specificity of tetrazolium compounds for the histochemical detection of succinic dehydrogenase has been given recently by Shelton and Schneider[9].

The rationale of the technique is as follows. Blue tetrazolium is ditetrazolium chloride and is pale yellow in aqueous solution; it is a hydrogen acceptor and becomes reduced to a blue water-insoluble pigment (diformazan). Fresh-frozen sections are placed in a substrate[8] containing 1 part of water, 1 part of 0·2 *M* sodium succinate, 1 part of 0·1 *M* phosphate buffer (*p*H 7·6) and 1 mgm. of blue tetrazolium per ml. The reaction develops in about two hours. We have found that by this time the maximum colour has developed, and that even leaving the sections over-night does not intensify the colour further. The succinic dehydrogenase in the tissues is, of course, responsible for the splitting of hydrogen from the succinate, and this reduces the tetrazolium to diformazan which, being insoluble, is precipitated at the site of enzyme activity.

We have investigated this reaction in guinea pig, rabbit, mouse and rat tissues. Technical points which we have found affecting the reaction are as follows.

(1) *Method of killing the animal.* Some animals were killed by anæsthetizing with chloroform, some by ether, some by 'Nembutal' injection and some by a blow on the head. In animals killed by the use of anæsthetics, it was difficult to obtain a satisfactory reaction for the enzyme, particularly with the liver and cardiac muscle. The reaction in kidney, brain and nerve appeared to be unaffected by the method of killing the animal except in the case of the rabbit, when it was almost impossible to obtain a result from any of the tissues after anæsthesia. A blow on the head appeared to be the most satisfactory way of killing the animal.

(2) *Thickness of sections.* Seligman and Rutenberg found that sections of 8 μ or less gave no reaction, and that sections 20 μ thick gave optimum results even though about one section in five gave no result. Presumably these negatives are due to oxidation of the diformazan, since a greater number of positive sections is obtained if oxygen is excluded from the system. Seligman and Rutenberg found that thicker sections than this were unsatisfactory. Shelton and Schneider agree with Seligman and Rutenberg in this respect. We have, however, obtained poor results with 20-μ sections, but have been able to obtain excellent and consistent results with sections of 50–100 μ.

Succinic dehy rogenase preparations
(1) Kidney (rabbit); note positive reaction in convoluted tubules; negative reaction in glomeruli. × 35
(2) Kidney (rabbit); note positive reaction in Henle's loops; negative reaction in lower collecting tubules. × 35
(3) Striated muscle (rabbit); note positive reaction given by rows of sarcosomes between muscle fibrils. × 1,000

(3) *Fixation.* We obtained our best results from sections which were not treated with any fixative—even acetone proved unsatisfactory. Seligman and Rutenberg hardened their sections after incubation by treatment with 10 per cent formalin for 30 min. The sections should be mounted in glycerine jelly or in Apathy's medium.

(4) *Freshness of buffer.* We found that it was essential to use freshly prepared buffer.

(5) *Sectioning the tissue.* We found that freezing the tissue in a drop of water for sectioning was less satisfactory than freezing it on its own and dropping the sections directly into the substrate solution.

Shelton and Schneider tested four tetrazolium compounds as indicators of dehydrogenase activity. These were neo-tetrazolium, blue tetrazolium, tetrazolium violet and 2,3,5-triphenyltetrazolium chloride. The first two of these were found to be satisfactory, the last two unsatisfactory. Neo-tetrazolium gave the most rapid reaction. These authors found that fresh tissues had some endogenous ability of reducing tetrazolium salts; but that this ability was for some unknown reason lost when the tissues were frozen. They found that crystalline lactic and alcohol dehydrogenases did not reduce tetrazolium salts in the presence of their substrates, but that purified xanthic oxidase and diphosphopyridine nucleotide–cytochrome *c*-reductase were able to reduce these salts. Nevertheless, under the conditions of the histochemical test when carried out on frozen sections, they consider the reaction reasonably specific for succinic dehydrogenase, although they do not deny that mediation by other enzymes may be involved. In our own experiments no reaction was obtained when the succinate in the reaction mixture was replaced by malate, fumarate, citrate or cysteine.

In the animals we have examined, we have investigated the distribution of the reaction in peripheral nerve, liver, heart muscle, skeletal muscle, kidney and cerebellum.

Like Seligman and Rutenberg, we found the kidney very rich in this enzyme, but we did not, as they did, find cardiac muscle to have greater activity: we found it to have less. We found kidney to have the highest activity, then cardiac muscle, skeletal muscle, cerebellum, liver and peripheral nerve. Our results with kidney agree with those of previous authors in that we found the cortex of the kidney very rich in activity but the medulla almost completely negative; in other words, as with alkaline phosphatase, the enzyme was localized in the metabolically active part of the kidney (the convoluted tubules and Henle's loops) and only in the beginning of the collecting tubules. Glomeruli were almost completely negative. Like Shelton and Schneider, we found little evidence of diffusion in our preparations, when the blue granular reaction was given. We were not able, however, to decide upon the significance of the diffuse purple reaction given by some tissues which Seligman and Rutenberg find accompanies regions of low activity.

In cerebellar tissue, the outer (molecular) layer of the cortex showed this diffuse coloration, which increased in intensity and reached its maximum colour at the junction with the inner (granular) layer. The Purkinje cells were of the same intensity as the surrounding tissue. In the granule layer the cells and processes stained a diffuse purple colour (the white matter of the cerebellum was completely negative), but in addition the cells contained blue granules. In some cases these were evenly distributed in the cytoplasm and in some cells there was a juxta-nuclear or peri-nuclear aggregation of granules which linked together to give a network-like appearance resembling the Golgi apparatus.

The liver, in addition to a diffuse purple background, showed blue granules in the cells and in some cells bright blue rods and filaments.

Peripheral nerve also gave a diffuse purple reaction, and faint blue granules could be seen in places; but it was not possible to be certain whether these granules were between or within the nerve fibres. The cells of the perineurium showed blue granules in many places.

The intra-cellular distribution of succinic dehydrogenase is of considerable interest since differential centrifugation studies have shown that the large-granule fraction (presumably composed chiefly of mitochondria) contains practically all the succinic dehydrogenase activity of the tissue. Shelton and Schneider found that the large-granule fraction reduced tetrazolium salts when incubated with them. They found that the mitochondria and masses of reduced tetrazolium (formazan) crystals formed a *matte*, but they were not able to see whether individual mitochondria were stained. These results support the view that considerable succinic dehydrogenase is localized in the mitochondrial fraction; and it suggests that a good deal of activity is localized in, or possibly adsorbed on, the surface of the mitochondria, but gives no information whether any further activity is present inside the mitochondria.

Our preparations of kidney and liver showed a granular formation in many of the cells which was identical with mitochondria; but much more striking were our preparations of skeletal muscle. Here we found closely packed chains of granules between the muscle fibrils which gave an intense positive reaction. There is no doubt that these granules, from their form and localization, are sarcosomes—elements which are known to be mitochondrial in origin and to contain enzymes identical with those present in the mitochondria of liver cells. We have found a similar localization of activity in the sarcosomes of heart muscle. Seligman and Rutenberg publish a photograph of heart muscle which also shows this; but they simply refer to it as granular and homogeneous deposits in the myocardial cells. Parts of our preparations (liver, kidney and muscle) show large amorphous granules and some show structures which are strikingly mitochordrial in shape and form. High-power observation of the amorphous granules suggests that these may represent mitochondria, on the surface of which a mass of formazan crystals has accumulated. The same thing occurs in a few of the sarcosomes of muscle. On the other hand, some mitochondrial-like bodies and most sarcosomes seem to be stained an intense dark blue with no obvious signs of formazan crystals on the surface. This appears to suggest that the enzyme causing this reduction is present within the mitochondria, although it may, of course, be associated with the mitochondrial membrane.

One of the criticisms of the work on the localization of respiratory enzymes in mitochondria as demonstrated by the technique of differential centrifugation is that the enzymes may be adsorbed on to the mitochondria from the homogenate; however, the papers of Seligman and Rutenberg and of Shelton and Schneider, together with the results of the present study, present strong evidence that succinic

dehydrogenase activity is closely associated with the mitochondria in the intact cell.

Since this paper was written, an extensive study of the histochemical reaction for succinic dehydrogenase has been published by Padykula[10]. In general, we agree with her results. She found also that, if sections were incubated in an atmosphere of nitrogen, much more consistent results were obtained.

We are indebted to Prof. E. W. Dempsey, of Washington University, St. Louis, for a supply of blue tetrazolium which was used in this work; also to Drs. Schneider and Shelton, of the National Institutes of Health, for a supply of neo-tetrazolium with which some of this work was confirmed.

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TRAVELLING-WAVE LINEAR ACCELERATOR FOR X-RAY THERAPY

By C. W. MILLER

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DURING the past three years a linear accelerator having a design energy of 10 MeV. has been undergoing development for the Medical Research Council. The work has been performed by the Metropolitan-Vickers Electrical Co., Ltd., in conjunction with the Atomic Energy Research Establishment, Harwell, and the Medical Research Council. The machine, which is the first of its kind to be built specifically for X-ray therapy, has now completed its performance tests and has been installed at the Hammersmith Hospital, London.

Brief descriptions of the construction of this machine have already appeared[1,2], and the design of the accelerating tube itself follows closely the theory published by members of the linear accelerator team from Harwell[3,4], much of the computation being carried out by them. The corrugated waveguide is 3 m. in length, has $a/\lambda = 0{\cdot}168$ and operates at a free-space wave-length of 10·0 cm. The corrugation pitch is 1 cm. over the first 40 cm., and 2 cm. over the remaining length of guide. The ratio of phase velocity to that of light is approximately 0·4 at the input end, increasing to 0·992 at 1 m. along its length and thereafter remaining constant at 0·996. Electrons are injected into the accelerator from a gun operating at 45–50 kV. The electron dynamics require a power flux of some 3·6 MW., and, as the radio-frequency power source provides pulses of 2 μsec. duration and 2 MW. peak power, feedback as described by Harvie and Mullett[5] is used.

In much of the experimental work the machine was operated with a target mounted directly on the end of the accelerating tube. For clinical use an X-ray head is fitted in which the electron beam is deflected through a right-angle before hitting the target. This head can be rotated about the axis of the accelerator to change the direction of the X-ray beam.

The first length of corrugated waveguide was manufactured to dimensions calculated from the theory given by Walkinshaw[4]. Low-power measurements on this section of guide showed that the phase velocity at the design frequency was in error by some 5 per cent. Dimensions for a second length of guide were determined by scaling from the experimental results, and this new guide was found to have the required velocity characteristics. The discrepancy between theory and the experimental results has been found, and Walkinshaw and Bell have, in as yet unpublished work, derived an alternative method which not only avoids this error but also gives more rapid convergence.

The accelerator was operated for the first time in December 1950 and has from the first given a very large X-ray output. Measurements have been made of beam current and power, electron energy and X-ray output, and the variation of these quantities as functions of the operating conditions, such as radio-frequency power and frequency, focusing field and electron injection current, has been investigated. By modification of sections of the guide, the performance of the machine with several different phases of electron bunching was determined. The variations obtained in these tests were qualitatively in agreement with theory, and from the curves obtained it was possible to determine the best arrangement for installation. For clinical operation, not only is it desirable that high current and energy be provided but also that, owing to the change in direction of the electron beam in the X-ray head, a narrow spectrum of electron energy is required, and variation of energy with input power and frequency must be minimized. Typical performance curves are shown in Figs. 1 and 2. By running at a somewhat higher power-level and increasing the recurrence-rate beyond the nominal maximum of 500 pulses/sec., greater outputs can be obtained. At 600 pulses/sec. the X-ray output may be increased to 1,000 r./min. at 1 m., while at 700 pulses/sec. an output of 1,250 r./min. has been achieved. Short-term stability of the equipment is good, while long-term stability is ensured by means of a servo-operated phase shifter[6] in the waveguide feedback circuit, to correct for frequency drift and temperature changes of the corrugated waveguide. X-ray output stabilization at a preset value is obtained by variation of the gun-filament current. The width of the X-ray beam produced, using a thick gold target, has been found to be 24·5° at half intensity. A beam-flattening filter is incorporated to give uniform intensity at 1 m. over a circle 26 cm. in diameter. The treatment area, normally rectangular, can be adjusted by means of sliding diaphragms down to a minimum of 3 cm. square, and for circular fields special diaphragms may be inserted. The diameter of the electron beam is approximately 3 mm., and the consequent small spot-size and stability of its position ensures an adequately small penumbra. In clinical use it is intended to operate at dose-rates up to 200 r./min. at 1 m. from the target, a normal single treatment thus requiring an exposure of the order of two minutes. This output is considerably below the maximum shown in Fig. 2 and allows for stabilization and losses in the X-ray head, including the beam-flattening filter.

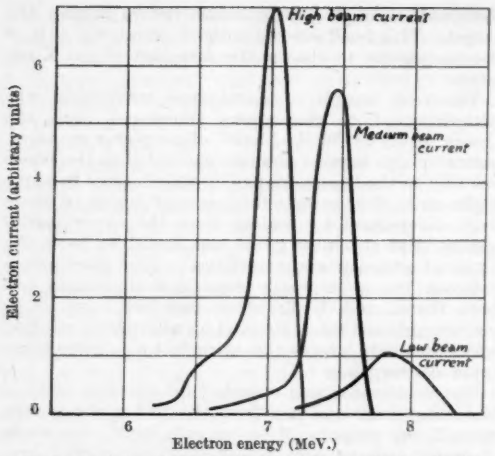

Fig. 1. Typical performance curves of linear accelerator, showing electron energy spectra

The conversion from electron current to X-ray output is 18·2 r./min./μA. at 1 m. for an energy of 8 MeV., while the exponent for the variation of this figure with energy is 2·87.

In general, the performance of the equipment has shown a close agreement with theory, with the exception that the electron energy is lower than was expected. An explanation which reconciles theory and measurement has been found as follows. In the design the relationship between accelerating field and power flux has been evaluated using the theory given by Walkinshaw[4]. In this the fields in the corrugated guide (E_ρ, H_φ and E_z) are given as an expansion in Bessel functions with coefficients A_0, A_1, etc. It is only the term with coefficient A_0 in the expansion for E_z which gives acceleration. Power flux is determined by the integration of the Poynting vector, $E_\rho \times H_\varphi$, and this, of course, leads to a further expansion. Following Walkinshaw, it had been assumed that only the term from the product of the two terms with coefficients A_0 was of significance, and from this assumption the relationship between the accelerating field and power flux was obtained. Further investigation shows that the assumption was not justified and that an appreciable part of the power flow is attributable to other terms in the expansion. The exact evaluation becomes difficult and has only been carried far enough to show that the effect can qualitatively explain the low energy. In order to obtain a quantitative relationship, measurements were made using a perturbation method based on the work of Maier[7] and Hansen and Post[8]. In these experiments the resonant frequency of a cavity constructed from a short length of corrugated guide is changed slightly by means of a metallic bead or piston. The fractional change in frequency together with the group velocity, determined by dispersion measurements, enables the relationship between the axial field and power flux to be calculated. Values obtained in this way confirm that the expected energy of the accelerator should have been approximately 8 MeV.

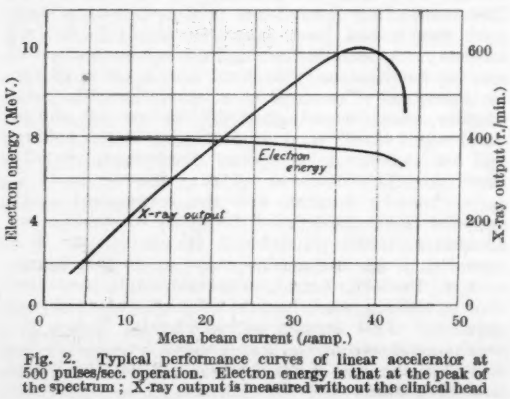

Fig. 2. Typical performance curves of linear accelerator at 500 pulses/sec. operation. Electron energy is that at the peak of the spectrum; X-ray output is measured without the clinical head

In the light of experience gained in this development, a 4-MeV. accelerator for clinical use has been designed, and several of these machines are at present being constructed. In this design the length of the corrugated guide is only 1 m., and the whole of the accelerator is mounted on a rotatable support. Considerable attention has been given to the simplification of the controls and of the facilities for the setting-up of the patient.

It is a pleasure to acknowledge the contributions of colleagues, and also the collaboration of the Atomic Energy Research Establishment and the Medical Research Council.

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HOMOLOGY OF THE LAYERS OF THE EPICUTICLE OF INSECTS

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THE insect epicuticle is known to be a complex structure, and the different views that have been put forward regarding its constitution have been difficult to reconcile. Wigglesworth has indicated the presence in *Rhodnius*[1], *Tenebrio*[2] and *Periplaneta*[3] of four epicuticular layers—the cuticulin, polyphenol, wax and cement layers. In contrast, Richards and Anderson had been able to demonstrate by different methods only two in *Periplaneta*[4], and later Dennell described a two-layered epicuticle in blowfly larvae[5]. Neither of the two layers described by these authors appeared to have its obvious counterpart in the description given by Wigglesworth. Now, however, comparison is aided by more detailed information on the epicuticle of *Periplaneta* and of the larva of *Calliphora*.

The innermost layer of the epicuticle of *Periplaneta* is the chitin-free cuticulin layer readily recognizable by its mosaic appearance[3]. When fully hardened, it shows no affinity for stains, and takes up sudan black *B* only after treatment with 'Diaphanol'. It gives a strongly positive argentaffin reaction, and fuses into oily droplets on heating with chlorated nitric acid. On the other hand, the newly formed cuticulin layer stains red with Mallory's

triple stain, and takes up sudan black without previous treatment due to the presence of lipoid now found to be of sterol type. The argentaffin reaction is positive but less intense than in the fully hardened cuticle. As Wigglesworth found in *Rhodnius*[6], hot concentrated solution of potassium hydroxide causes complete dissolution. The newly formed cuticulin layer therefore bears a striking resemblance to the inner layer of the epicuticle of blowfly larvæ. In *Sarcophaga* the 'inner epicuticle' or 'protein epicuticle' stains red with Mallory, dissolves in hot concentrated potassium hydroxide solution, and gives only a slight argentaffin reaction and sudan black staining[5]. In *Calliphora*, however, it is strongly argentaffin[5], and on re-examination has been found to contain a sterol. It seems, therefore, that the inner epicuticle must be regarded as homologous with the cuticulin layer of the cockroach, the differing properties that have been ascribed to this layer being due to the observation of differing degrees of impregnation of a basal protein matrix with steroid and fu..her protein and their subsequent polymerization, and to tanning in the hard cuticle. A further indication of homology is that both the inner epicuticle of blowfly larvæ[7] and the cuticulin layer of the cockroach[9] contain a polyphenol oxidase at the time of hardening.

Overlying the inner epicuticle of blowfly larvæ is the very thin but resistant outer epicuticle or 'lipoid epicuticle'[5]. Its disruption into oily droplets on strong heating in chlorated nitric acid caused it to be wrongly regarded as cuticulin[10]. Like the inner epicuticle, it does not contain chitin. Isolated as already described[5], it has been further studied in *Calliphora*. It shows a strong X-ray diffraction pattern of paraffin-chain type and, in spite of the method of preparation, a weak diffuse protein pattern. The infra-red spectrum shows great C—H absorption with strong evidence of the presence of fatty acid esters. Micro-chemical analyses show that the nitrogen content amounts to only about 1 per cent. The outer epicuticle differs then from the cuticulin layer in containing not a steroid but a straight-chain paraffin.

Does such a thin layer of great stability occur also in hard cuticles? As is to be expected, it is found in puparia, and may be isolated by its persistence after treatment with 'Diaphanol' followed by hydrochloric acid. Richards and Anderson[4] found a resistant outer layer in the cockroach, and this observation has been amply confirmed in the present work. The soft cuticle of the newly moulted cockroach has been macerated and a very thin non-mosaic membrane lifted here and there from the underlying cuticulin layer. Where it remains in contact with the cuticulin layer, it is not histologically distinguishable, but a uniformly lifted cement layer is clearly seen. In the adult cuticle a thin stable membrane has been isolated by the treatments used for blowfly puparia. It is noteworthy that Wigglesworth[1] also has shown the presence in *Rhodnius*, before the secretion of the cement layer, of a superficial layer of greater resistance than the underlying cuticulin layer. Both cuticulin and the superficial layer, however, yielded oily droplets on dissolution in chlorated nitric acid, and Wigglesworth did not regard the two layers as chemically different. But the paraffin-containing outer epicuticle of *Calliphora* also yields oily droplets, and it is suggested here that the thin resistant layer of the cockroach cuticle is a paraffin-containing layer homologous with that of *Calliphora*. Unfortunately, sheets of this layer from the cockroach are not sufficiently robust to be examined by X-ray diffraction and infra-red absorption methods.

Turning now to the polyphenol layer of Wigglesworth's scheme, this is said to be formed as a discrete layer by the spreading and fusion of argentaffin droplets secreted at the tips of the pore canals[1,2]. But later the areas reducing ammoniacal silver nitrate are less prominent[2], and Wigglesworth's observations seem to permit the view that the argentaffin secretion may impregnate underlying layers in preparation for the hardening process. This is further suggested by the fact that these layers, when first laid down, do not give the argentaffin reaction[1,2], whereas at the time of moulting the test is positive before the general tanning of the cuticle begins. With regard to the nature of the argentaffin droplets it seems unlikely that a polyphenol is involved. The ferric chloride test is negative[2], and the argentaffin test is not specific for polyphenols. It has been shown in the cockroach cuticle[9] that, during preparation of the outer procuticle for tanning, a protein giving the argentaffin reaction is passed into a zone already occupied by a steroid, and it is suggested here that the 'polyphenol' secretion is a protein which similarly impregnates the sterol-containing cuticulin layer as a preliminary to the tanning process. Richards[8] admits the possibility that the polyphenol layer may be dispersed by, and modify, the underlying layers. In the view presented here, then, the polyphenol layer is not regarded as a constituent layer of the epicuticle.

To summarize, the insect epicuticle is regarded, in the light of our present knowledge, as basically comprising an innermost layer, the protein epicuticle, which during development of the cuticle is impregnated first by a steroid and then by an additional protein. It may then undergo quinone tanning to become the fully formed cuticulin layer described by Wigglesworth. The impregnating protein of the cuticulin layer may be secreted by the tips of the pore canals. Overlying the cuticulin layer is a very thin, chemically stable, paraffin-containing layer, the lipoid epicuticle. In some cuticles a cement layer may protect or be embedded in a wax or grease layer. In the accompanying table this view of the epicuticle is compared with that of Richards[8] and of Wigglesworth[1].

Richards	Wigglesworth	Dennell and Malek
Tectocuticle	Cement layer	Cement layer
Lipoid epicuticle	Wax layer	Wax layer
Queried	Polyphenol layer	Not recognized as a discrete layer
Lipoprotein layer	More resistant surface of cuticulin layer	Lipoid or paraffin epicuticle
Basal protein layer	Main mass of cuticulin layer	Protein epicuticle which may be impregnated with steroid and protein to form cuticulin layer

We are indebted to Dr. K. M. Rudall for kindly making the X-ray diffraction and infra-red absorption observations for us. A more detailed account of the observations which form the basis of the views presented here will be given elsewhere.

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LETTERS TO THE EDITORS

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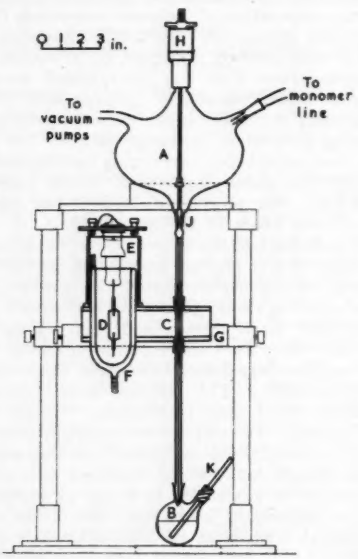
A Flow Method for the Synthesis of 'Block' Copolymers

Two methods of synthesizing 'block' copolymers have been reported in a recent communication from these laboratories[1]. Whereas both these methods involve a static system, it has now proved possible to conduct a similar kind of synthesis using a flow technique. Polymer radicals derived from one monomer are introduced into a second monomer; their continued growth leads to the production of block polymer. The type of apparatus used for these experiments is shown in the diagram.



Monomer containing photo-sensitizer (1-azo-1-*bis*-*cyclo*hexanoic carbonitrile) flows down a vertical capillary (*C*) into a receiver (*B*). The rate of flow can be varied by means of a stainless steel valve (*J*) at the top of the capillary. Since oxygen is an inhibitor of vinyl-type polymerizations, all operations are carried out *in vacuo* and the valve is controlled externally from a vacuum-tight metal bellows attachment (*H*). Very high concentrations of free radicals (up to 10^{-4} mole/litre) are produced at any desired point inside the capillary by focusing into it a large proportion of the radiation from a 125-W. high-pressure mercury lamp (*D*). This is achieved by using an elliptical cylinder of stainless steel strip (*G*), highly polished on its interior surface to act as a reflector, the lamp being housed at one focus of the ellipse and the capillary at the other. The input rate, as determined by uranyl oxalate actinometry, is $2{\cdot}8 \times 10^{-7}$ Einsteins/sec. in the region of absorption by the sensitizer; the volume of liquid under illumination is only 0·03 ml.

In order to test the feasibility of introducing polymer radicals into the receiver, butyl acrylate was chosen as monomer since it has an unusually low rate coefficient for termination ($1{\cdot}8 \times 10^4$ litre mole^{-1} sec.$^{-1}$ at 15° C.)[2]; at the rates of more than 100 per cent polymerization per hour inside the capillary, the life-time of the radicals is of the order of one second. The concentration of radicals attained inside the capillary depends on the length of the zone of illumination, the concentration of the sensitizer and the rate of flow of the monomer. It is essential in this method that the radicals emerging from the capillary should be dispersed immediately in the monomer contained in the receiver, thus increasing their life-time. Forced vibrations set up in a spring-steel strip (*K*) prove efficient for this purpose. Under these conditions the amount of polybutyl acrylate formed in the receiver is highly dependent on the number of radicals reaching it, namely, on the rate of flow and the distance of the mirror from the receiver. This may be seen from the accompanying table, in which v is the velocity of the monomer, P the concentration of polymer radicals at distance d from the mirror, F_1, F_2 the calculated amounts of 'dead' polymer formed in the illumination zone and the capillary respectively, and F the total amount of polymer formed.

v (cm./sec.)	30	18·5	15·3	9·9	7·2
d (cm.)	20	9	10	10	10
$P \times 10^3$ (moles/lit.)	0·42	1·0	1·4	2·2	2·5
$F_1 + F_2$ (gm./lit.)	0·04	0·07	0·15	0·43	0·83
F (calculated), gm./lit.	0·75	1·29	1·91	2·45	3·25
F (obtained), gm./lit.	0·9	1·12	1·95	2·5	3·4

The calculations are based on the theory of the non-stationary phase of chain reactions[3] and on general considerations of flow systems. It is possible to calculate F_2, the amount of polymer formed in the receiver; if a value of 40 sec. is assumed for the time required for polymerization in the system to cease, then the calculated values for F are in agreement with those obtained from refractometric measurements. The amounts of polymer formed in the system are given by:

$$F_1 = \frac{k_p}{k_t} \cdot \ln\left(\cosh \frac{t_1}{\tau}\right), \quad F_2 = \frac{k_p}{k_t} \cdot \ln\left(1 + k_t . P_M t_2\right)$$

$$\text{and } F_3 = k_p \int_0^{10} P.dt,$$

where k_p and k_t are the rate coefficients for propagation and termination, t_1 and t_2 are the times spent by the monomer in the zone of illumination and afterwards in the capillary, τ is the life-time of the radical in the stationary-state treatment, and P_M is the maximum concentration of radicals attained in the system. The table also shows that $(F_1 + F_2)$ is much less than F, that is, most of the polymer radicals are terminated in the receiver and not inside the capillary. It should be possible to control the chain-lengths of the polymer radicals before they react with the second monomer, and the only restriction on the preparation of 'tailored' block polymers from a variety of monomer pairs is that the radicals from one monomer must react with the second monomer.

So far, two types of block polymer have been synthesized by this method. After running polybutyl acrylate radicals into styrene monomer, the polymer was isolated under such conditions that further thermal copolymerization was negligible. These runs were carried out at high rates of flow, so that the amounts of pure polybutyl acrylate formed and the percentage of this polymer in the block polymer were small. Ultra-violet analysis indicates a polystyrene content of approximately 72 per cent by weight.

The second type was made by running polyacrylonitrile radicals into styrene monomer, analysis indicating 76 per cent polystyrene in the product. It was soluble in chloroform only with difficulty. None of the turbidity usually associated with the heterogeneous polymerization of acrylonitrile was observed in the capillary. Since it has been demonstrated in a blank experiment that the polymer formed cannot be due to sensitizer radicals reaching the styrene, it appears that the initial stages of acrylonitrile polymerization may be homogeneous.

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University of Birmingham. Nov. 10.

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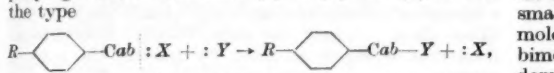
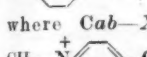
Effects of Alkyl Groups in Nucleophilic Substitution

This communication refers mainly to the polar effects of alkyl groups in S_N2 reactions, in structural circumstances in which steric factors are absent. Rate comparisons showing the effects of methyl and *tert.*-butyl substituents are summarized in the accompanying table. Reactions (1) to (7) and (9) are of the type



where Cab—X is, for example, CH_2—hal.,  , CO—OEt, or CO—hal., and : Y = $\bar{I}$, $\bar{O}H$ or $\bar{O}R$ (the dots represent electrons). Reactions (1)–(6) are of the second order, being of the first order with respect to each of the reactants specified. In the solvolytic process (7), the reagent (ethanol) is in large excess and the reaction is of the first order. It is probable, however, that this change is also substantially bimolecular[1]. Reaction (9) is a first-order replacement at a saturated carbon atom under conditions especially conducive to a unimolecular mechanism[2]. It was included in order to obtain a comparison of the effects relating to the two main substitution mechanisms, S_N2 and S_N1. Reaction (8) is a second-order nucleophilic replacement; but it should be noted that, in contrast to the other changes, it occurs at an aromatic carbon atom.

The polar requirements of the unimolecular mechanism (reaction 9) are clear. The rate-determining process consists of the separation of the expelled group with the electrons of the C—X bond, and it should be facilitated unconditionally by electron release to the reaction centre. Consistently, it is observed that the *p*-alkyl substituents in reaction (9) give rise to a large increase of rate. The results show that *p*-Me has a greater capacity for electron-release than *p*-Bu^t, and they thus confirm a previous demonstration of C—H hyperconjugation influences in suitably situated alkyl groups[3].

In the bimolecular mechanism, the polar requirements are not so clear-cut. In this single-stage process, bond formation occurs simultaneously with bond fission; and, while bond fission should, as before, be facilitated by electron-releasing alkyl groups, the approach of the nucleophilic reagent, which is necessary for bond formation, should be hindered by these substituents. The net result is a difference effect; and, while it is not possible in general terms to make a simple prediction of its direction, the magnitude of the effect of a given substituent in S_N2 reactions may be expected to be smaller than the corresponding influence in S_N1 replacements. In reactions (1)–(4), alkyl groups increase the rate of substitution; but in examples (5)–(8) these substituents decrease the rate. In all cases, the observed effects are considerably smaller than the corresponding influences in unimolecular substitution (reaction 9). In the first set of bimolecular processes, bond-fission requirements are dominant, and the facilitating electron-release effects from the methyl substituents are greater than those from the *tert.*-butyl groups. In the second set, bond-forming requirements are dominant and the (now inhibiting) electron-releasing power of Me is again greater than that of *t*-Bu. The rate sequence *p*-H > *p*-Bu^t > *p*-Me has also been observed for the reaction of 2-nitrobromobenzenes with pyridine, and confirmatory results have been obtained for reaction (6)[4].

The results, as a whole, show that C—H hyperconjugation effects, which are available in the *p*-methyl derivatives but not in the *p*-Bu^t-compounds, are of importance in bimolecular nucleophilic substitution under the conditions used. It should be emphasized that, because of the marginal requirements of S_N2 reactions, coupled with the dual

Reaction Rates showing Polar Effects of Alkyl Groups
(k_2 in sec.$^{-1}$gm.-mol.$^{-1}$lit.; k_1 in sec.$^{-1}$)

Reaction	Solvent	Temperature (° C.)	Rates for various *p*-substituents	H	Me	Bu^t
1. (*p*)*R*.C_6H_4.CH_2.Br + I^-	Me_2CO	0·0	$k_2 \times 10^2$ =	2·89	4·23	3·92
2. (*p*)*R*.C_6H_4.CH_2.Br + EtO^-	EtOH	25·1	$k_2 \times 10^2$ =	1·84	2·73	2·54
3. (*p*)*R*.C_6H_4.CH_2.Br + Bu^{t}O$^-$	Bu^{t}OH	60·0	$k_2 \times 10^3$ =	3·75	5·03	4·46
4. (*p*)*R*.C_6H_4.CH_2.Cl + EtO^-	EtOH	25·1	$k_2 \times 10^3$ =	3·72	5·85	5·45
5. (*p*)*R*.C_6H_4.CH_2. + EtO^-	EtOH	20·0	$k_2 \times 10^4$ =	4·01	2·02	2·77
6. (*p*)*R*.C_6H_4.CO.OEt + OH^-	85 per cent (wt.) EtOH—H_2O	25·1	$k_2 \times 10^4$ =	7·18	3·13	4·42
7. (*p*)*R*.C_6H_4.CO.Cl + EtOH	EtOH	0·0	$k_1 \times 10^5$ =	7·89	4·49	5·26
8. (*p*)*R*.$C_6H_3(NO_2)_2$.Cl + EtO^- (2 : 6-dinitrochlorobenzenes)	EtOH	50·0	$k_2 \times 10^3$ =	14·7	2·59	4·55
9. (*p*)*R*.C_6H_4.CH_2.Br + H_2O	$H.CO_2H$	25·1	$k_1 \times 10^7$ =	3·68	213	103

behaviour of alkyl substituents, changes in experimental conditions (for example, temperature, solvent) may produce different rate sequences. Our extensions of these investigations will include a study of the Arrhenius parameters of the reactions under various experimental conditions, and we postpone further discussion of the effects until additional observations are available.

Note added in proof (*cf. ref.* 4). See *J. Amer. Chem. Soc.*, **74**, 4940 (1952); because of differences in experimental conditions the absolute rate coefficients, for identical esters in the parallel investigations, are appreciably different, but the rate ratios, *p*-*R*/*p*-H, are in closer agreement.

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Reticulin and Collagen

A recent letter by Little and Kramer[1] reporting some studies on reticulin prompts the submission of a preliminary account of some similar investigations now in progress. Attempts to determine the relation between collagen and reticular fibres using the electron microscope to examine teased-out or otherwise broken-down tissues are open to the criticism that the fibres observed are not histologically identifiable. Kramer and Little appear to have overcome this objection and to have reached the conclusion that the fibrils of reticulin have the same structure as collagen fibrils—a conclusion which the following experiments confirm.

The reticulin of adult rat and human spleens has been investigated using two different procedures. In the case of rat spleen, the method was to cut 10-μ frozen sections which were mounted on collodion films on fine stainless steel mesh, and then to digest these sections with pancreatin until only the fibrous elements of the connective tissue remained. After thoroughly washing and drying, suitable pieces of mesh were cut out, the specimens shadowed with palladium and examined in the electron microscope. Apart from the collapse of the material on to the film on drying, the fibrous network is very little disturbed, and reticulin could be identified as branching and anastomosing networks of fine fibres, quite distinct from the relatively massive bundles of collagen. In all cases the reticular fibres showed the same characteristic cross-banding as is shown, for example, by rat tail tendon, a true collagen.

Collagen fibres from human spleen capsule after silver impregnation. × 20,000

The human spleen material was treated differently. A fresh spleen was cut into slices of about 5 mm. thickness, well washed and then digested in pancreatin until only a fibrous network remained. A well-washed slice of this material was fixed in formalin, washed, dehydrated and finally embedded in a camphor-naphthalene medium. This was sectioned at 10 μ, the sections being mounted on collodion films on glass. The embedding material was removed by sublimation *in vacuo*—a process which minimizes disturbance of the fibres. Optical micrographs of these preparations were compared with those of ordinary histological preparations of spleen, silver-impregnated and stained with Van Gieson's fluid. From this comparison the reticular fibres in the collodion-mounted specimens were clearly identified, and these fields were examined in the electron microscope after palladium shadowing. Again the reticular fibres show precisely the same banded structure as does true collagen obtained by teasing the splenic capsule.

It seems, therefore, beyond doubt that the fibres of reticulin are morphologically identical with those of collagen. This does not necessarily imply that the two kinds of fibre are identical in all respects. Indeed, their responses to the Bielchowsky–Foot silver impregnation technique are markedly different and remain to be explained. This phenomenon of argyrophilia is at present under investigation. The accompanying photograph is of human spleen capsule fibres teased out after Foot silver impregnation, and shows that the metal is deposited as particles of colloidal dimensions on the fibres, and is not a chemical combination with them. It would appear that silver staining is an interface phenomenon occurring at the fibre – ground substance boundary, and may depend more upon variations of the latter than on differences in the fibres.

These studies are continuing and will be published fully elsewhere.

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Photo-insolubilization of Dextran

The insolubilization of many dichromate-sensitized protein dispersions, notably albumins, gelatins, etc. after exposure to light, is well known and is the basis of most photo-engraving procedures[1]. Polysaccharides, such as starch and gum acacia, and polysaccharide derivatives such as methyl cellulose and, more recently, surface-hydrolysed cellulose esters[2], similarly become insoluble when exposed to light in the form of thin, dry films.

It has been shown recently in these laboratories that dextran, a poly-glucose obtained by the fermentation of sucrose by a number of organisms, more particularly *Leuconostoc* species, also exhibits photo-insolubilization, a property which is very clearly demonstrable with the water-soluble dextran produced by the *L. mesenteroides* organism described by Stacey and Swift in 1948 [3]. Degradation of the macromolecule[4] produces nitrogen-free fragments which can be separated into homologous polysaccharide fractions of differing molecular sizes. It has been shown that these degraded polysaccharides are also capable of being photo-insolubilized, and the interesting discovery has been made that there appears to be a relationship between molecular size (expressed in terms of viscosity) and light sensitivity.

In general, preparations with molecular weights in excess of one million show a greater speed of insolubilization as compared with preparations having molecular weights of less than 500,000. Preparations with mean molecular weights in the region of 300,000 show rates of insolubilization comparable with the proteins conventionally used in photo-mechanical processes. Variation of dichromate concentration does not appear to affect the rate of insolubilization, that is, the general sensitivity of these dextrans, to any marked degree.

After heating for two minutes at an optimum temperature of 250° C., the insoluble image has been found to be resistant to etching acids.

A more detailed account of this development will be published elsewhere.

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Sept. 3.

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Effects of some Chelate Compounds upon the Formation *in vitro* of Melanin

It is said that cupric ions accelerate the autoxidation of 3,4-dihydroxyphenylalanine (dopa)[1] and, on the other hand, that they combine with pterins, riboflavin, amino-acids and other organic substances to form chelate complexes[2]. We have therefore carried out some experiments to investigate the behaviour of metal-bound pterins and riboflavin in relation to the rate of oxidation of dihydroxyphenylalanine.

Fig. 1 gives the results of manometric measurements indicating that the oxidation of dihydroxyphenylalanine is much more highly accelerated by the presence of both folic acid and cupric sulphate than by the presence of the latter alone, while folic acid itself appears to have no effect. The rate of blackening of the solution appears to be higher than that due to oxygen uptake, in the presence of both substances. Xanthopterin behaves similarly, and is more active than folic acid in the presence of cupric ions, whereas leucopterin does not accelerate the oxidation even if accompanied by cupric ions.

These results suggest that pterins, when they form chelate compounds with certain metals, behave like enzymes in accelerating the autoxidation of dihydroxyphenylalanine, their activities being different

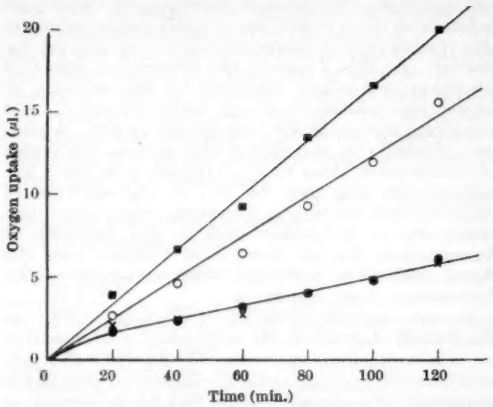

Fig. 1. Acceleration of oxygen uptake by dihydroxyphenylalanine due to the chelate compound of folic acid and cupric ions (*p*H 7·3, 37·5° C.).
—●—, 0·5 c.c. of *M*/15 phosphate buffer solution and 1·8 c.c. of distilled water in the main chamber.
—×—, 1 c.c. of distilled water in the first preparation replaced by 1 c.c. of 80 mgm. per cent folic acid suspension.
—○—, 0·5 c.c. of distilled water in the first preparation replaced by 0·5 c.c. of 10^{-3} *M* cupric sulphate solution.
—■—, 1·5 c.c. of distilled water in the first preparation replaced by 0·5 c.c. of 10^{-3} *M* cupric sulphate solution and 1 c.c. of 80 mgm. per cent folic acid suspension.
Each of the side arms of the manometric flasks contained 0·5 c.c. of 60 mgm. per cent solution of dihydroxyphenylalanine, which was transferred into the main chamber at 0 hr. Each of the wells contained 0·3 c.c. of 10 per cent solution of potassium hydroxide

according to structures of their rings. In this connexion, the investigations of E. L. Smith[3] were of much interest to us, for they interpret enzymic activities by rather simple principles which fundamentally are based upon the chelation of organic substances with metallic ions.

Riboflavin, the photodynamic accelerator of the autoxidation of dihydroxyphenylalanine[4], is also known to form larger complexes by capturing

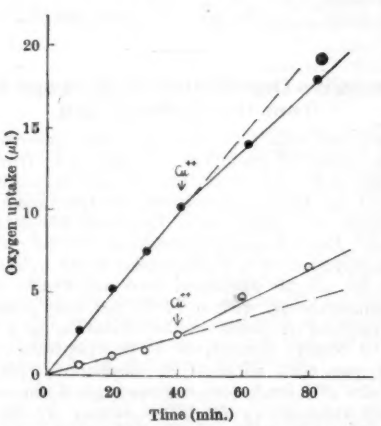

Fig. 2. Effect of riboflavin on oxygen uptake by dihydroxyphenylalanine, before and after the addition of cupric ions, under irradiation with a 200-W. tungsten lamp (*p*H 7·3, 37·5° C.).
—○—, 1 c.c. of 60 mgm. per cent solution of dihydroxyphenylalanine, 0·5 c.c. of *M*/15 phosphate buffer solution and 0·8 c.c. of distilled water in the main chamber.
—●—, 0·5 c.c. of distilled water in the first preparation replaced by 0·5 c.c. of 10^{-4} *M* solution of riboflavin.
Each of the side arms of the manometric flasks contained 0·5 c.c. of 10^{-3} *M* solution of cupric sulphate, which was transferred into the main chamber 40 min. after the beginning of measurement. Each of the wells contained 0·3 c.c. of 10 per cent potassium hydroxide

metallic ions[2]. We therefore examined this substance before and after it was mixed with cupric sulphate. Our results show a sharp contrast to those given by pterins. As Fig. 2 shows, the accelerating effect of riboflavin was much hindered by the addition of cupric ion which, if added independently, could accelerate the oxidation to a certain extent. A mixture of riboflavin and copper also showed less degree of acceleration than that of riboflavin alone. We believe that this may be due to the decrease of photodynamic activity of riboflavin, which was found previously to be proportional to the intensity of fluorescence[4], for we found that contact with the metal resulted in a considerable weakening of the fluorescence from riboflavin.

Another example of the effect of chelation may be mentioned. Zinc ion is the only metallic ion reported to accelerate the conversion of dopa-chrome (red substance) to leuco-substance—the second step in the formation of melanin[5]. This can be confirmed in Thunberg tubes. We prepared dopa-chrome by adding sodium hydroxide to dihydroxyphenylalanine. After neutralizing with hydrochloric acid, we put it into a Thunberg tube, de-aerated and mixed it with zinc sulphate at *p*H 6·3. The red colour disappeared gradually. Now, if xanthopterin was added to this system, the time of decolorization was prolonged somewhat. This again may be attributed to the capture of the metallic ion by xanthopterin, for the latter alone could have little effect upon this step.

Further details of our investigations will be published elsewhere.

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Stepwise Degradation of Polypeptides from the Carboxyl End

Many methods have already been described for the selective degradation of peptides from the carboxyl end[1]. However, the several chemical steps involved in those procedures do not allow their utilization on a micro-scale. Linstead, Shephard and Weedon[2] have recently published a study on the decarboxylation of α-N-acylamino-acids in alcoholic media by anodic oxidation into alkoxyalkylamides (acylaminoethers), with a 74–91 per cent yield.

We applied the same anodic oxidation on a micro-scale to N-acyl derivatives of polypeptides (1 cm.³ of 0·1 per cent solution in methanol; platinum electrodes of 1 cm.² total surface area, 3 mm. apart; 200–250 volts, D.C.; 50–150 m.amp.; 10–30 min.; 0° C.). The initial amino-acid of the acylated peptide (I) is decarboxylated into (II):

The initial amino-acid no longer appears on a paper chromatogram of the hydrolysis products of (II). If (II) is heated for a short time with dilute aqueous hydrochloric acid, the methoxyalkylamide is hydrolysed into (III). After evaporation to dryness *in vacuo* and re-dissolution in dry methanol, (III) is decarboxylated by a new anodic oxidation into (IV). The spot of the second amino-acid is no longer detectable on a chromatogram of the hydrolysis products of (IV).

By this simple method, which involves only manipulations easily carried out on a micro-scale, polypeptides were degraded stepwise from the carboxyl end, and the sequence of amino-acids was determined by their successive disappearance on chromatograms after hydrolysis.

We found that Sanger's dinitrophenyl derivatives of peptides may also be submitted to carboxyl anodic oxidation. Thus, time and material are saved by combining Sanger's method for the determination of the amino terminal amino-acid with our new method for the determination of the carboxyl terminal amino-acid.

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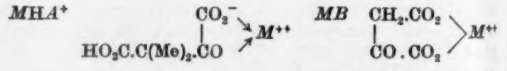
Metal Ion Catalysis of the Decarboxylation of Oxalo-Acetic Acid

In order to explain the catalysis of oxalo-acetic acid decarboxylation by metal ions, intermediate complex formation between the metal ion and the acid anion has been postulated. In an attempt to determine the nature of this complex, Steinberger and Westheimer[1] studied the kinetics of the decarboxylation of the dimethyl substituted acid. In this way they showed that the catalysis did not proceed through an enolic form of the acid. From a further consideration of the general characteristics of decarboxylation reactions, they suggested that the metal complex involved in the catalysis had the formula, *MA*, which was formed from MHA^+, by the loss of a proton.



Pedersen[2] examined the catalytic decarboxylation of the parent acid in greater detail. He obtained, from kinetic data, a stability constant of 10^4 for the formation of a cupric complex of the acid, and suggested that this complex was of the same kind as

MA. Now *MA* is a complex of an α-keto acid, and another complex, *MB*, could also have been formed. The latter is a complex of a dicarboxylic acid. The measurement of the stability constants for the formation of both types of complex together with the observation of Pedersen might then be used for describing in more detail the suggested mechanism of the catalysis. The data for the dicarboxylato-complexes are available from the literature, and we have measured the stability of the complexes of pyruvic acid in order to make this comparison (see table).

LOGARITHM OF THE STABILITY CONSTANTS OF CERTAIN METAL COMPLEXES

Ligand	pk_1	pk_2	log K_{Cu}	log K_{Zn}	Ref.
Malonic acid	2·85	5·70	4·80	3·68	7
Succinic acid	4·19	5·48	3·33	2·70	7
Oxalo-acetic acid	2·30	3·88	4·00	—	2
Tartaric acid	2·88	3·94	—	2·68	8*
Acetic acid	4·75	—		1·57	7
Glycollic acid	3·71	—	—	1·92	8*
Pyruvic acid	2·35	—	2·50	2·10	

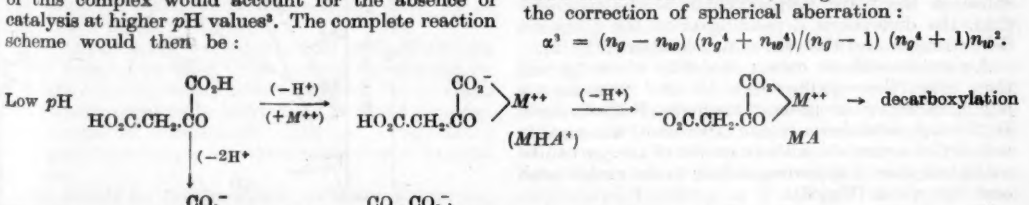
* Measured at ionic strength 0·2.

The data show that the stability constants of both the zinc and the cupric complexes of dicarboxylate anions have considerably larger values than those of the pyruvates. The value Pedersen[2] obtained is much nearer the former, and this might suggest that his complex constant referred to the formation of a complex of formula *MB*. However, the formation of the two complexes MHA^+ and *MB* is controlled by the *p*H such that the relative amounts of each are given by :

$$\frac{[MHA]}{[MB]} = \frac{K_1.[H]}{K_2.k_2}, \qquad (1)$$

where K_1 and K_2 are the stability constants for the formation of the complexes MHA^+ and *MB* respectively, and k_2 is the second acid dissociation constant of oxalo-acetic acid. From the data in the table and equation (1), the two different complexes might be expected in equal amounts at about *p*H 2·0–3·0. Below this *p*H the complex MHA^+ would predominate. It is to be expected that *MA* will only form in the *p*H range in which *MHA* is formed rather than *MB*. Now *MA* will have a different stability constant, K_3, from MHA^+ or *MB*, such that $K_3 = \frac{K_1.k_2}{k_3}$, where k_3 is the acid dissociation constant of MHA^+. As $k_2 < k_3$, Pedersen's constant, K_3, would be expected to be greater than K_1—as is found—and the determination of stability constants does not discriminate between *MA* and *MB*.

At higher *p*H values the formation of *MA* or *MB* need not proceed through MHA^+, and either one of the two complexes will be formed, depending only upon their relative stability. It is to be anticipated that *MB* will be the more stable, and the formation of this complex would account for the absence of catalysis at higher *p*H values[3]. The complete reaction scheme would then be :



The rate of some other catalysed hydrolyses have somewhat similar features to the above decarboxylation[4]; but it is of particular interest that the catalysis of many enzymatic reactions is similar to that described[5], and in particular that this catalysis also goes through a maximum with *p*H. The recent work of Albert[6] has illustrated further the importance of the formation of two different complexes from the same ligand and metal ion.

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Newton's Work on Geometrical Optical Aberrations

IN Newton's "Opticks" (editions of 1704, 1717 and 1721 and the subsequent editions and translations, so far as we have been able to ascertain) an erroneous condition is given for the proportion α of the radii of a symmetrical thin triplet (the inner lens being of water) in order to correct the system for spherical aberration for distant objects. Calling the curvature of the first and second surface R_1 and R_2 respectively, the formula gives $\alpha^3 = (R_1/R_2)^3 = (KK-KI)/(RK-RI)$, where $R/I = n_g$, the refractive index of the two outer (glass) lenses, and $R/K = n_w$, the refractive index of the inner (water) lens. The fraction can be simplified to K/R, and gives a large amount of under-correction.

No indication is left of the deduction of the condition. The correct and complete form is : $a\alpha^3 + b\alpha^2 + c\alpha + d = 0$, where a, b, c and d are functions of a high degree in n_g and n_w. This form cannot by any reasoning be simplified to a cube root condition for α.

By means, however, of an unwarranted application of the formula for the spherical aberration of a single spherical surface for a parallel incident pencil, as given by Newton in "Lectiones Opticæ", I, Prop. 31, a curious result is obtained. When we transfer the angular aberration of the first surface to the image space by multiplication by $(n_g/n_w) . (n_w/n_g) . (n_g/1)$, doing the same for the aberration of the second surface with the factor $(n_w/n_g) . (n_g/1)$, for the third surface with the factor $n_g/1$, and adding the contributions of the four surfaces, we get the condition for the correction of spherical aberration :

$$\alpha^3 = (n_g - n_w)\,(n_g^4 + n_w^4)/(n_g - 1)\,(n_g^4 + 1)n_w^2.$$

Within the range of refractive indices for glass in Newton's time, it appears that the factor $(n_g^4 + n_w^4)/(n_g^4 + 1)n_w^2$ is practically constant and equal to $1/n_w$. Thus the condition for α can be written: $\alpha^2 = (n_g - n_w)/n_w(n_g - 1) = (KK - KI)/(RK - KI)$. With the value of α following from it, the spherical aberration, indeed, is considerably reduced—to about 0·6 that of a single lens of best form (to reduce spherical aberration).

If this, indeed, was originally meant by Newton, only one letter in the formula had been erroneously printed; that the error is present in each edition can be explained by the fact that Newton had no interest in this condition on account of the chromatic aberration, which, according to him, was always present and larger, and which led him to the construction of a reflecting telescope.

Each of the letters of the original formula has been changed into one of the other possible letters; but the change as given above is the only one which leads to a better correction.

It was further ascertained that the correction outside of the axis for distant objects by means of a symmetrical thin ('cemented') triplet is always much worse than for a single lens of approximately convex-plane form, at least unless enormous amounts of spherical aberration are being introduced. This means that the Scholium to Prop. 98 of the first book of the "Principia" is either incorrect or refers to a non-symmetrical triplet.

It would be worth while, we think, to look into what is left of Newton's papers and letters to see if there is any indication that he had worked in this direction.

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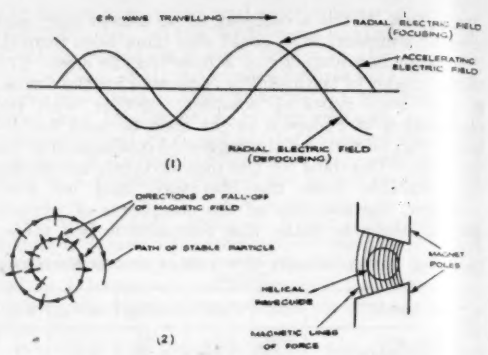
A Heavy-Particle Accelerator

A method of overcoming the defocusing effect of the electromagnetic wave in the Walkinshaw heavy-particle accelerator[1] has been suggested by Chick and Petrie[2]; an alternative solution to the problem is here proposed.

If the stable position for the particle bunch on the travelling wave could be made to lag in phase from the normal position by an angle between 90° and 180°, it would then be in a region of focusing instead of defocusing radial forces[3,4] (Fig. 1). For stability in this region, however, it is necessary that a particle which loses energy shall gain in phase on the electromagnetic wave, and vice versa. It is suggested that this can be achieved by introducing a constant magnetic field gradient across the helical guide, the axis of which should then be made to take the form of a spiral in the plane perpendicular to the magnetic field, the dimensions depending upon the magnetic field-strength and the rate of acceleration (Fig. 2).

A particle with an excess or deficit of energy will then leave the equilibrium orbit and pass into a region of lesser or greater magnetic field-strength. In the non-relativistic region, therefore, the angular velocity of a particle with an excess of energy can be made less than that corresponding to the stable orbit and vice versa (Fig. 3).

The above mechanism will be modified by the presence of the radial electric focusing forces, which are the differential of the accelerating field. Phase



stability will therefore be dependent upon both the magnetic field and the accelerating field.

It may be shown that phase stability exists if:

$$n \geqslant \frac{\pi r_0^2}{2\lambda_g E} F_0 \cos\theta_1,$$

where $n = \frac{r_0}{H_0}\frac{dH}{dr}$; r_0 is radius of stable orbit; λ_g is wave-length of accelerating field in the guide $\left(= \frac{v}{c}\lambda_a\right)$; λ_a is wave-length of accelerating field in air; v is velocity of particle; c is velocity of light; E is kinetic energy of the particle; F_0 is maximum value of electric accelerating field multiplied by charge on the particle; θ is phase angle defined as $\theta = 0$ for zero accelerating field. It may also be shown that radial focusing exists if:

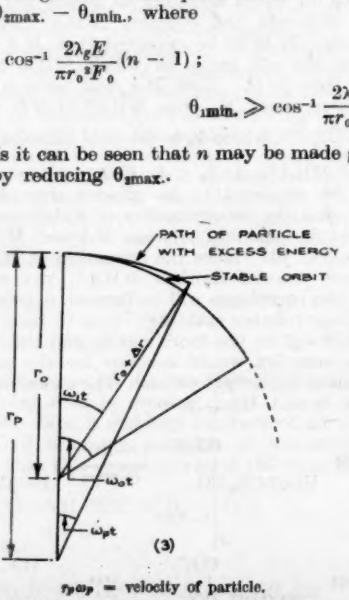
$$n - 1 \leqslant \frac{\pi r_0^2}{2\lambda_g E} F_0 \cos\theta_2.$$

The phase angle over which particles will be captured will be $\theta_{2max.} - \theta_{1min.}$, where

$$\theta_{2max.} \leqslant \cos^{-1}\frac{2\lambda_g E}{\pi r_0^2 F_0}(n-1);$$

$$\theta_{1min.} \geqslant \cos^{-1}\frac{2\lambda_g E}{\pi r_0^2 F_0} n.$$

From this it can be seen that n may be made greater than 1 by reducing $\theta_{2max.}$.



$v_p\omega_p$ = velocity of particle.

Phase stability if, for $v_p/v_0 > 1$, $d\omega_1/dt$ is negative, and $v_p/v_0 < 1$, $d\omega_1/dt$ is positive

Since $\frac{\lambda_g E}{r_0^2} \propto H_0^3$, we have $H_0^3 \propto \frac{1}{n-1}$,

and H_0 will therefore be smaller for larger values of n; from which it follows that the separation between successive revolutions will be greater for larger n. Advantage might have to be taken of this in a practical design to avoid the injector on the second revolution.

Using available figures[1,2] as typical operating conditions, we find for protons: injection energy, 2 MeV.; radio-frequency, 300 Mc./s.; F_0, 25 keV./cm.; n, 1; r_0, 20 cm.; H_0, 10 k.gauss; $\theta_{2\max.} - \theta_{1\min.}$, 90°; energy gain in first revolution, 3 MeV. approximately; distance between first and second orbits, 12 cm. approximately. For $n = 1$, $\theta_{2\max.} = \pi/2$, so that the phase stability condition becomes dominant. Hence, for a constant value of $\theta_{1\min.}$ and $n = 1$, H_0 will vary along the stable orbit as $E^{-1/4}$. Thus orbit separation may be increased as acceleration proceeds. Following the reasoning adopted by Thomas[5], the focusing and defocusing effects of so reducing the magnetic field along the stable orbit should cancel.

I wish to acknowledge the help I have received from discussions with members of the Radiotherapeutic Research Unit, in particular P. H. Flanders, during the preparation of this communication.

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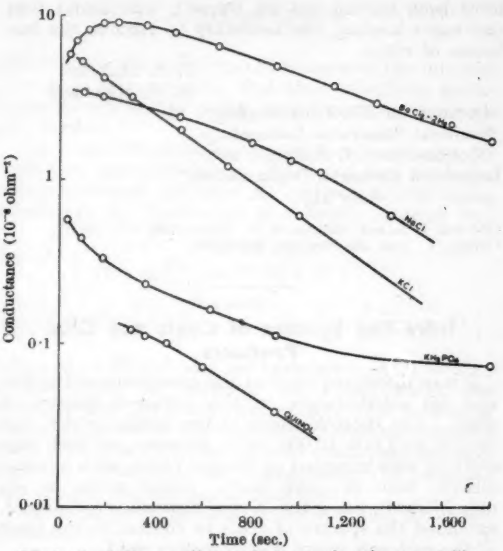
Electrical Conductivity of Certain Crystalline Materials after Grinding

IT was recently reported[1] that quinol shows a large increase in low-frequency dielectric loss on grinding. The effect is temporary and decreases with time. It has now been found that this phenomenon is more general and occurs with many inorganic salts and some crystalline organic compounds.

In these materials the dielectric properties of the lightly pressed crystals before grinding are such that the loss factor increases with decreasing frequency and ultimately rises in proportion to $1/f$ (where f is frequency); it is assumed that the loss factor in the latter region is entirely due to D.C. conduction. On grinding, the magnitude of the low-frequency dielectric loss factor increases at all frequencies, often by as much as a factor of 1,000.

The experiments were performed with electrodes in the form of bevelled brass pistons surrounded by a polystyrene cylinder, which enabled the grinding and measurement to be carried out in rapid sequence in a controlled atmosphere. The A.C. conductance at a particular frequency was measured as a function of time.

The results for four inorganic salts and for quinol, dried for several weeks over calcium chloride and then ground in air over calcium chloride, are given in the accompanying graph. Smaller effects were



Effect of grinding on the conductance of various crystalline materials at 16 kc./s.

Values of conductance before grinding (10^{-8} ohm^{-1}): $BaCl_2.2H_2O$, 0·16; KH_2PO_4, 0·022; NaCl, 0·017; KCl, 0·005; quinol, 0·004

observed with urea, copper sulphate and resorcinol; and other compounds, such as sugar, paraffin wax and 4 : 4′-dihydroxy-diphenyl, gave no measurable effect.

Several grinding experiments were performed with these electrodes in a vessel which could be evacuated or filled with any desired atmosphere. It was observed that the rate at which the A.C. conductance decreased, following the initial increase on grinding, was more rapid the lower the relative humidity of the surrounding atmosphere. Also, the equilibrium value of the A.C. conductance was less the lower the relative humidity. At pressures below about 5 mm. of mercury, no increase in A.C. conductance was observed on grinding. Moreover, if the increase had already been produced by grinding in a normal atmosphere, it was eliminated by evacuation.

The effect was not present in sodium or potassium chloride, or in quinol which had been thoroughly dried by heating and then ground in an atmosphere over phosphorus pentoxide. Even when such thoroughly dried materials were ground in the laboratory atmosphere, the increases in conductivity were small. On prolonged exposure to the laboratory atmosphere, the return to the state giving a large grinding effect was comparatively slow, particularly with sodium chloride.

The results of this work suggest that the low-frequency dielectric properties of these materials before grinding arise from the presence of highly conducting regions at the crystal surfaces due to adsorbed layers of water. Also, there is some water (or solution) held in the crystals, possibly in small cracks, which, on being released by grinding, distributes itself over the freshly created surfaces. The water present on these surfaces in excess of that in equilibrium with the surrounding atmosphere then evaporates, resulting in a decrease in the D.C. and A.C. conductances.

In connexion with these results, extensive experiments on the adsorption of gases on sodium chloride

have been carried out by Durau[2], who found that prolonged heating was necessary to remove the last traces of water.

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Infra-Red Spectra of Coals and Coal Products

I was interested to read the comments of Gordon and his collaborators on the infra-red spectra of coal[1]. The spectral range of our earlier work[2] was limited to 1,000–10,000 cm.$^{-1}$, because our first thin sections were mounted on fluorite plates with a transmission limit of 1,000 cm.$^{-1}$. Later work, as yet unpublished[3], using the 'Nujol' dispersion technique[4], extended the spectra of coals to 650 cm.$^{-1}$, the limit of the rock-salt prism spectrometers used.

Spectra of eighteen samples of bright coals (that is, mainly vitrain) of varying rank from Warwickshire, Northumberland, Yorkshire and South Wales were recorded. Humic acids, and pyridine and aniline extracts from several of the coals, were also examined. Most of the strong absorption bands were assigned to specific chemical groups present in the coal structure. The results and major conclusions are briefly summarized here.

The general level of absorption intensity was constant for the lower-rank coals. The general absorption intensity was higher for a coking coal and very much higher for a low-volatile steam coal. Gordon's spectrum of an anthracite[1] is almost devoid of structure except at the low-frequency end. Graphite examined in 'Nujol' at the same pathlength as used for the coals was completely opaque from 5,000 cm.$^{-1}$ to 650 cm.$^{-1}$. A 'Nujol' dispersion *c.* 2 μ thick showed a continuous structureless absorption of 70–80 per cent over this spectral range. This marked increase in general absorption for the high-rank coals can be correlated with the development of optical anisotropy[5], and with orientation and growth of crystalline regions found in X-ray diffraction studies[6]. It seems to mark the beginning of a transition from an aromatic structure (see below) towards a graphite-type structure.

The general similarity in the spectra of coals of all ranks examined (except anthracite[1]) suggests that the molecular skeleton remains practically unchanged. As one might expect from the decrease in oxygen content with increase in rank, bands which can be assigned to oxygen-containing groups (OH, C=O, C—O—, etc.) decrease in intensity with increase of rank. The main absorption assigned to the C—O— stretching-frequency occurs in the region of 1,250 cm.$^{-1}$, suggesting that the OH groups are mainly phenolic rather than aliphatic hydroxyl.

The molecular structure seems very complex, but the C—H and —C=C— stretching frequencies, and the CH out-of-plane deformation frequencies near 880, 820 and 750 cm.$^{-1}$, when correlated with the spectra of a large variety of aromatic compounds[7], indicate the presence of both single ring and condensed aromatic structures. Aliphatic CH_3- and CH_2-groups can be detected. Two carbonyl frequencies have been found; the stronger, near 1,690 cm.$^{-1}$, probably arises from aldehyde or keto-groups, while the second, near 1,730 cm.$^{-1}$, suggests the presence of a smaller proportion of ester groups.

For a low-rank coal, the spectrum of the material extracted by pyridine was practically identical with that of the parent coal.

A study of the hydroxyl frequencies in the spectra recorded suggests that hydrogen bonding between hydroxyl groups is one of the factors determining the physical structure of coals. Orchin and Storch[8] have postulated a hydrogen-bonded structure for coal, following their work on solvent extraction. Dryden[9] has briefly discussed the significance of the spectroscopic results and the part played by hydrogen bonding in the solvation of coals.

The humic acid spectra were clearly different from those of the parent coals, and had features in common with graphitic acid and mellitic acid (hexacarboxybenzene).

As Gordon *et al.* have noted[1], pitch extracts exhibit spectra bearing a remarkable resemblance to the coal spectra. Hadzi[10] has studied the spectra of a variety of coal and tar extracts and has identified chemical groupings also found in the coal spectra.

The results summarized above, which were obtained several years ago, will be published in detail elsewhere.

I am indebted to Prof. G. B. B. M. Sutherland for his guidance during the course of this work, and to the late Dr. D. H. Bangham for his interest and encouragement. Thanks are also due to Prof. R. G. W. Norrish for facilities kindly provided in the Laboratory of Physical Chemistry, Cambridge. The research was sponsored by the British Coal Utilization Research Association and permission to publish this work is gratefully acknowledged.

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A Trigonometric Series used in Physical Problems

In connexion with a boundary-value problem in room acoustics, we were led to consider the following trigonometric series. It has been noted further that certain other trigonometric series encountered by K. S. Krishnan[1,2] and L. S. Goddard[3] in different physical situations can be obtained as special cases of the above series.

The series concerned is:

$$\sum_{n=1}^{\infty} \frac{\sin(n+\theta)x}{n+\theta} \cdot \frac{\sin(n+\varphi)x}{n+\varphi} = A(\theta,\varphi\,;\,x), \text{ say,}$$

$$0 < x < \pi,$$

and $A(\theta,\varphi\,;\,x)$ can be expressed as

$$\frac{1}{2}\frac{\cos(\theta-\varphi)x}{\theta-\varphi}\,[\psi(1+\theta)-\psi(1+\varphi)]+$$

$$\frac{1}{2}\frac{\cos(\theta-\varphi)x}{\theta-\varphi}\,[c(\theta,2x)-c(\varphi,2x)]+$$

$$\frac{1}{2}\frac{\sin(\theta-\varphi)x}{\theta-\varphi}\,[s(\theta,2x)+s(\varphi,2x)],$$

where

$$\psi(z)=\frac{\Gamma'(z)}{\Gamma(z)},\quad c(\theta,x)=\sum_{n=1}^{\infty}\frac{\cos(n+\theta)x}{n+\theta},$$

$$s(\theta,x)=\sum_{n=1}^{\infty}\frac{\sin(n+\theta)x}{n+\theta}.$$

The transformations for $c(\theta,x)$ and $s(\theta,x)$ were obtained by G. H. Hardy[4].

Putting $\theta=\varphi$ and taking the sum of $A(\theta,\theta\,;\,x)$ and $A(-\theta,-\theta\,;\,x)$, one obtains the result (Krishnan, *loc. cit.*) :

$$\sum_{n=-\infty}^{\infty}\frac{\sin^2(nx+\alpha)}{(nx+\alpha)^2}=\frac{\pi}{x}.$$

Putting $\theta=-\varphi=\alpha m$ $(\alpha>1,\ m=1,2,3\ldots)$ and $x=\pi/\alpha$, one obtains (Goddard, *loc. cit.*) :

$$\sum_{n=1}^{\infty}\frac{\sin^2(n\pi/\alpha)}{n^2-\alpha^2m^2}=0.$$

The corresponding series involving the cosines, namely,

$$\sum_{n=1}^{\infty}\frac{\cos(n+\theta)x}{n+\theta}\cdot\frac{\cos(n+\varphi)x}{n+\varphi}=B(\theta,\varphi\,;\,x),\ \text{say},$$

can also be treated in the same manner.

The last series can be used to obtain the result

$$\sum_{n=-\infty}^{\infty}\frac{\cos^2(nx+\alpha)}{(nx+\alpha)^2}=\left(\frac{\pi}{x}\right)^2\left[\operatorname{cosec}^2\left(\frac{\pi x}{\alpha}\right)-\frac{x}{\pi}\right].$$

The details of the calculations and certain other results will be published elsewhere.

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Multiple Meson Production

It has recently been reported by Daniel *et al.*[1] that in high-energy collisions between nucleons, besides π-mesons, some heavier mesons of about 1,300 m_e mass are also created. The purpose of the present note is to estimate the theoretical probability of emission of a heavy meson in a collision process, using the statistical theory developed by Fermi[2]. The collision is studied in the centre-of-mass system of the particles and it is assumed that the total energy W (W is the energy in the centre-of-mass system) is suddenly released in a small volume,

$$\Omega=\frac{4\pi}{3}(\hbar/\mu c)^3 2Mc^2/W,$$

surrounding the nucleons (M = mass of the nucleon, μ = mass of π-meson). One then calculates statistically the probability that a certain number of mesons are created.

On a suitable modification of Fermi's results, we find that the probability, $P(s,n)$, of two nucleons, s heavy mesons (of mass K) and n π-mesons being present in the final state of collision, is given by :

$$P(s,n)=\frac{8\cdot5}{(2+s)^{3/2}}\,\frac{(29\cdot3/\omega)^{s/2}}{\{(6n+3s+1)/2\}!}$$

$$\left\{\frac{6\cdot31}{\omega^{1/2}}\left(\omega-2-\frac{2}{3}s\right)\right\}^{2n+\frac{3}{2}s+\frac{1}{2}}\exp\left\{-\frac{6\cdot31}{\omega^{1/2}}(\omega-2)\right\}$$

where $\omega=W/Mc^2$ and we have taken $K/M=2/3$; $\mu/M=0\cdot15$. In deriving the above result the nucleons and the heavy mesons have been treated in the non-relativistic approximation, whereas π-mesons have been treated in the extreme-relativistic approximation. Further, the conservation of angular momentum has not been considered.

The table gives the results obtained from the above formula.

ω	Energy of primary particle in laboratory system	Average number of π-mesons produced when no heavy meson is created	One heavy meson is created		Ratio of the number of heavy mesons to π-mesons created in a collision
			Probability of the event*	Average number of π-mesons produced	
3	$3\cdot5\ Mc^2$	1·2	7		$\simeq$ 1/17
4	7·0 "	2·5	9	1	$\simeq$ 1/29
5	11·5	3·5	11	2·2	$\simeq$ 1/34
6	16·9	4·4	12	2·3	$\simeq$ 1/39

* The probability of the event when no heavy meson is produced is taken to be 100.

It will be noticed that, for collisions involving primary energies up to about 20 Mc^2, the possibility of a heavy meson being created is small. (The relative probability of two or more heavy mesons being created is very small and does not alter the conclusions drawn. For very high energies the above formula breaks down.) The slightly higher ratio of the number of heavy mesons to that of π-mesons, near the threshold energy for the creation of a heavy meson, will also be observed. This is due to the fact that, according to this theory, the probability of creation of a heavy meson varies more slowly with increasing energy than does the average number of π-mesons created.

In the extremely high energy region, where the heavy mesons and the nucleons have also to be treated in the extreme relativistic approximation, it follows from thermodynamic considerations[2] that the number of heavy mesons produced will be comparable to the average number of π-mesons, the ratio being governed mainly by the ratio of their respective statistical weight factors.

I am grateful to Mr. J. Hamilton for his interest in the work. I am also indebted to the Government of India for the award of a scholarship.

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Mean Square Radius of randomly coiled Molecular Chains

An expression for the mean square radius of a randomly coiled long-chain polymer, that is, for the mean square distance of its constituent groups from their centre of mass, was first derived by Debye[1]. Debye's formula applies only to very long chains; the following simple derivation is valid for any unbranched chain, provided the correlation between two atoms depends only on the number of links separating them (this implies neglect of the excluded volume effect).

According to a theorem by Lagrange[2], in a system of n particles the mean square distance R_n^2 of the particles from their mass centre is given (in the case of equal masses) by:

$$R_n^2 = \sum_i r_{Gi}^2/n = \sum_{i,j} r_{ij}^2/n^2. \quad (1)$$

Here the r_{Gi} denote the distances of the individual particles from the mean centre and the r_{ij} their mutual distances; the double sum has to be taken over all pairs of particles (once only). If the particles are arranged in the form of a chain and the average is taken over all possible configurations of the chain, equation (1) leads to:

$$n^2 < R_n^2 > = \Sigma < r_{ij}^2 > = (n-1) < r_{12}^2 > + (n-2) < r_{13}^2 > + \ldots + < r_{1n}^2 >, \quad (2)$$

where the signs $< >$ denote statistical averages.

For links of constant length l_0 and mutually independent directions:

$$< r_{1j}^2 > = (j-1)\, l_0^2, \quad (3)$$

which yields with the use of (2):

$$< R_n^2 > \simeq \frac{1}{6} l_0^2 (n - 1/n) = \frac{1}{6} < r_{1n}^2 > (1 + 1/n). \quad (4)$$

For a constant valency angle $\pi - \omega$ and free rotation about bonds, it is known that[3]:

$$< r_{1j}^2 > = l_0^2 \left[(j-1)\frac{1+\alpha}{1-\alpha} - 2\frac{\alpha - \alpha^j}{(1-\alpha)^2} \right], \quad (5)$$

where $\alpha = \cos \omega$. Substitution of this into (2) yields

$$< R_n^2 > = \frac{l_0^2}{n^2} \left[\frac{1}{6}\frac{1+\alpha}{1-\alpha}(n^3 - n) - \frac{(n-1)\alpha}{(1-\alpha)^2}\left(n - \frac{2\alpha}{1-\alpha}\right) - \frac{2(\alpha^3 - \alpha^{n+2})}{(1-\alpha)^4} \right]. \quad (6)$$

More complicated correlations can be treated in an analogous way. In all cases in which there is no preferential tendency for the chain to develop in any specific direction in space, Debye's result[1] is obtained for large n, that is:

$$< R_n^2 > = < r_{1n}^2 > \left[\frac{1}{6} + O(n^{-1}) \right]. \quad (7)$$

The subject of this note formed part of the fundamental research programme of the British Rayon Research Association.

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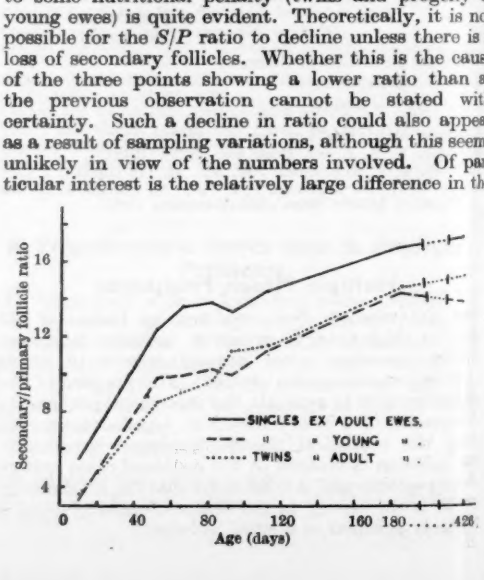
Follicle Development in the Australian Merino

So far as we are aware, there is no published information of a quantitative nature on the post-natal development of the follicle population in the skin of the merino sheep, although Carter and Hardy[1] have presented quantitative data for the pre-natal period. In his classical description of the development of the follicle group, Carter[2] was concerned with descriptive morphology and ontogenic considerations rather than with quantitative aspects. His clear definition of the two follicle types (primary and secondary), their relative place in the developmental sequence, and their fundamental arrangement in group form lays the foundation on which quantitative considerations may be built. The most satisfactory measure of the progress of development of the follicle population is the ratio of secondary follicles to primary follicles (S/P). The validity of this unit rests on the observation (Carter[2]) that the primary population within any region is determined by approximately the eighty-sixth day of pre-natal life, and that only secondary follicles develop thereafter. While it has not been proved that no primary follicles develop after this time, the histological evidence is heavily in this direction.

Unpublished observations at this College on causes of variability in the skin and fleece of merino sheep have shown that, at fifteen months of age, the S/P ratio of twins is frequently lower than that of singles, and those for the progeny of young ewes are also lower than those of mature ewes. It was decided, therefore, to study the development in these classes from early post-natal life. Skin sections were taken from the mid-side at 10, 52, 66, 82, 92, 113, 185 and 426 days of age, a single section of 1 cm. diameter being taken from each animal at each sampling period.

These sections were examined histologically by a method which was essentially the same as that described by Carter[3]. The accompanying graph shows the relationship between the S/P ratio and age in three groups of lambs taken at random from a flock of South Australian (Bungaree) merino.

The consistently lower ratio in those groups subject to some nutritional penalty (twins and progeny of young ewes) is quite evident. Theoretically, it is not possible for the S/P ratio to decline unless there is a loss of secondary follicles. Whether this is the cause of the three points showing a lower ratio than at the previous observation cannot be stated with certainty. Such a decline in ratio could also appear as a result of sampling variations, although this seems unlikely in view of the numbers involved. Of particular interest is the relatively large difference in the



S/P ratio at ten days of age, when the first sections were taken. This difference appears to be too large to have developed since birth, and strongly suggests that the late pre-natal development of secondary follicles may be affected by the fœtal environment. In a further series of observations, a significant correlation ($r = 0.56$) between birth-weight and *S/P* ratio at birth has been noted, and seems to establish beyond doubt that the ratio at birth is influenced by the general pre-natal environment. Subsequent observations have also shown that the rate of development of secondary follicles during early post-natal life is closely associated with growth-rate in general and particularly with rate of expansion of skin.

These observations form part of a larger series being conducted at this College, and financed largely by the Commonwealth Scientific and Industrial Research Organization from the Wool Research Trust Account; grateful acknowledgment is made for this assistance. The detailed observations will be published elsewhere in due course.

P. G. Schinckel

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May 21.

[1] Carter, H. B., and Hardy, M. H., Coun. Sci. Indust. Res. (Aust.), Bull. 215 (1947).
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Inhibition of Populations of *Hæmonchus contortus* in Sheep fed on White Clover (*Trifolium repens*) High in Lotaustralin

Melville *et al.*[1] have shown that strains of New Zealand white clover (*Trifolium repens*) may contain up to 0·033 per cent hydrogen cyanide. It occurred to me that such a concentration might be lethal to internal parasites of sheep.

Preliminary *in vitro* experiments demonstrated that solutions of potassium cyanide, approximating to the concentration of hydrogen cyanide which could be expected in the rumen of sheep fed on white clover, killed some trichostrongylid infective larvæ. Further, some infective larvæ in water exposed over macerated clover also were killed.

A third step was to administer known populations of *Hæmonchus contortus* infective larvæ to lambs reared free from parasitism and fed on pure stands of the following plants: (1) New Zealand certified pedigree white clover, a strain selected and bred by the Grasslands Division of the Department of Scientific and Industrial Research, high in the cyanogenetic glucoside, lotaustralin; analysis at the initiation of the experiment revealed 0·023 per cent hydrogen cyanide. (2) Red clover (*T. pratense*) containing a doubtful trace of hydrogen cyanide (white clover of low cyanide content was not available at the time of the experiment). (3) Cocksfoot (*Dactylis glomerata*), a grass chosen because it was available and did not contain hydrogen cyanide.

Fourteen seven-month old Romney lambs were simultaneously placed in each of the three parasite-free experimental paddocks. The lambs were permitted four days to become accustomed to the diet, and then each was given 2,000 *H. contortus* infective larvæ. After fourteen more days in the paddocks, the lambs were killed and the *H. contortus* populations counted. Only fifth-instar parasites were found. The average *H. contortus* populations for the groups were: on white clover, 509·6 worms; on red clover, 613·9 worms; on cocksfoot, 698·6 worms. Thus the average populations of the white and the red clover groups were, respectively, 72·9 and 87·8 per cent of the cocksfoot group. The average differences required for significance between the groups at the 5 per cent and 1 per cent levels are, respectively, 121·9 and 163·1. Thus it is seen that there is a highly significant difference in worm populations between the white and the cocksfoot groups; but between these two groups and the red clover group, population differences do not reach the 5 per cent level of significance. There is doubt that cyanide content is the only factor involved. The work is being continued.

I am indebted to the following officers of the N.Z. Department of Scientific and Industrial Research: Messrs. L. Corkill, L. W. Gorman and P. Sears of the Grasslands Division, for provision of the experimental areas and plants; to Mr. J. G. Fraser of the same Division, for chemical analyses; and to Mr. A. C. Glenday of the Applied Mathematics Laboratory, for statistical treatment of data. The work is being financed with the aid of a grant from the Department of Scientific and Industrial Research.

J. H. Tetley

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Palmerston North, New Zealand.
May 20.

[1] Melville, J., Coop, I. E., Doak, B. W., and Reifer, I., *N.Z. J. Sci. and Tech.*, **22** B, 144 (1940).

Action of Insulin on the Frog (*Rana temporaria*)

Earlier investigations of the action of insulin on cold-blooded vertebrates have shown that, although large doses usually lead to the appearance of typical convulsions, there is often a long latent period (1–2 days at room temperature) during which there are no visible symptoms[1–3]. In experiments performed in March and May 1952 the action of insulin on the blood-sugar level of the frog was followed, at intervals, from the time of injection to the development of convulsions. The frogs were kept at room temperature (17°–20° C.) and were injected with four units of insulin (Wellcome 40) in the dorsal lymph sac. The sugar content of the blood was determined by a modification of the method described by King[4] for obtaining "true sugar" values, which are 15–20 mgm./100 ml. lower than those previously recorded for the frog[5].

There was no change in the mean blood-sugar level in the first 1½ hr. after insulin ($23 \pm 1{\cdot}81$ mgm./100 ml.), but after 5 hr. it had fallen to a very low value ($3 \pm 0{\cdot}69$ mgm./100 ml.), which was maintained to the end of the experiments when the frogs had shown typical insulin convulsions[1,2]. In one series of experiments (May 1952) parallel estimations of the glycogen content of the liver and gastrocnemius muscles were made (calculated as percentage wet weight of tissue). The mean muscle-glycogen content fell slightly between 5 hr. and 24 hr. after insulin (from $0{\cdot}53 \pm 0{\cdot}06$ to $0{\cdot}32 \pm 0{\cdot}06$ per cent, $P < 0{\cdot}05$), possibly followed by a further decrease associated with the occurrence of convulsions ($0{\cdot}23 \pm 0{\cdot}05$ per cent). The changes in liver-glycogen content in the first 24 hr. were not significant, but after convulsions had occurred there was a marked fall (from $1{\cdot}71 \pm 0{\cdot}13$ to $0{\cdot}36 \pm 0{\cdot}22$ per cent, $P < 0{\cdot}001$).

In the light of the above experimental results the following hypothesis is put forward to account for the delayed appearance of insulin convulsions in the frog. The first action of insulin is a marked depression of glycogenolysis in the liver[4,7], perhaps accompanied by increased uptake of glucose by the tissues, leading to the development of an extremely hypoglycæmic condition. The frog then utilizes its peripheral carbohydrate stores for its energy needs, as suggested by the decrease in muscle glycogen. In general, the carbohydrate reserves of the central nervous system are considerably lower than those of the muscles, and it may be assumed that they would be the first to be exhausted. When this occurs the typical insulin convulsion appears. These convulsions have been observed to be accompanied by marked temporary contraction of the melanophores[2], suggesting the release of adrenaline which presumably also causes mobilization of some of the liver glycogen. This glucose production by the liver is responsible for the rapid recovery of the frog, which then appears quite normal for a few hours. Eventually another convulsion occurs, and the cycle is apparently repeated until the liver reserves are exhausted, when death occurs. Such a hypothesis also accounts for the fact that the time required for the appearance of convulsions depends on the environmental temperature rather than on the dose of insulin[1,3]. It has, in fact, been pointed out that the graph of the rate of action of insulin at various temperatures corresponded very closely to the curve for oxygen consumption[1].

Experiments on fish have shown that there is a correlation between the rate of action of insulin and the activity of the fish[3], and also that in a given species the former varies with temperature[2]. This suggests that the mode of action of insulin in certain fishes may be similar to that proposed for the frog.

C. L. Smith

Department of Zoology,
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Sept. 12.

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Heat Inactivation of Strawberry Viruses

The first and most effective measure for the control of virus diseases of strawberries is the provision of healthy planting material. Selection on the basis of virus tests has resulted in a virus-free clone of the Royal Sovereign variety and revived its commercial cultivation; but except for the recently bred variety Auchincruive Climax, no plants of other widely grown varieties have been found without at least a mild crinkle virus.

Experiments on heat therapy of strawberry plants infected with crinkle viruses were started in 1950, using a thermostatically controlled water-bath and a laboratory oven. It was found that although plants would survive only seven hours in water at 35° C., they would survive up to seven days in the oven at 33° C. Graft tests to the sensitive indicator, *Fragaria vesca*, in 1951 and again in 1952, showed that the mild crinkle virus had been inactivated in one plant (var. Perle de Prague) by oven treatment, and that one plant of Huxley's Giant had a reduced virus content.

In 1952, a propagation frame was adapted by the addition of thermostatically controlled heaters and double glazing, which gave temperature regulation within 2° C. In a series of experiments, young plants, growing in 3-in. pots and with all but the youngest leaf removed, were subjected to 37 ± 2° C. for periods ranging from five to twelve days. After a recovery period of about two weeks, the surviving plants were infested with non-infective aphids, *Pentatrichopus fragæfolii* Cock., which were transferred after 24 hr. to test plants (*Fragaria vesca*). Virus was always transmitted from unheated control plants in comparable tests. The heated plants which gave no virus transmission were re-tested with aphids, and those again yielding no virus were grafted to *F. vesca* plants. Apparently complete virus inactivation has occurred in plants of the varieties Early Cambridge, Huxley's Giant and Perle de Prague, and their clonal propagation is proceeding rapidly. The application of heat therapy to other varieties will follow.

Work on technique and on the determination of precise heat inactivation periods for different viruses is still in progress; the results obtained so far which may be useful to other investigators are summarized as follows.

The lowest temperature-time at which inactivation occurred was 33° C. for six days. Although some plants were killed, eight days at 37° C. gave the most reliable results; eleven days was the longest time any plant survived at this temperature.

Three viruses have been inactivated, which are, in the probable order of their sensitivity to heat: (*a*) an undescribed virus which causes severe leaf necrosis on Royal Sovereign and bud proliferation on *F. vesca*; (*b*) the mild crinkle virus (virus 1)[1]; and (*c*) the crinkle virus (virus 3)[2]. The yellow-edge virus (virus 2)[3] was not included in these experiments.

Plants previously thought, on the basis of vector and graft tests, to be infected with single viruses have been shown to contain at least two, one of which is inactivated more rapidly than the other.

Some plants which had given no virus transmission by aphids a few weeks after treatment gave transmissions when tested three months later, presumably owing to 'resurgence' of virus from deep-seated tissues.

Plants in the frame with daylight survived 37° C. for three days longer than did those in the dark oven. Warm water killed strawberry plants more quickly than did air at the same temperature, and plants survived longer incubation when the soil was moistened daily to prevent wilting than when saturated. Well-rooted plants withstood heat treatment better than recently potted plants.

The difference between varieties shown in the proportion of plants surviving heat treatment is thought to be due mainly to different susceptibility to fungal infection (for example, by *Botrytis cinerea*) under these conditions of high humidity and temperature. More plants survived in a sterile medium, 'Vermiculite', than in steam-sterilized soil.

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Nov. 27.

[1] Prentice, I. W., and Harris, R. V., *Ann. App. Biol.*, **33**, 50 (1946).
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Cytoplasmic Particles in Bean Root Cells

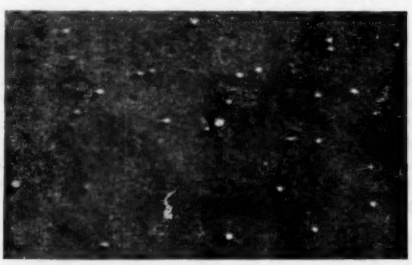
In the course of an investigation of the composition of certain aqueous extracts of tissues from the bean root, the material was examined in an electron microscope. Small spherical granules, slightly smaller in size than the microsomes described by Claude[1], Brachet and Jeener[2], and Stern[3], were detected. The size of the particles varied with the maturity of the tissue from which they were taken.

Bean seeds were germinated and sections cut from roots of standard length using the techniques previously described[4]. Aqueous extracts were prepared from sections cut from the regions 0–2·0; 7·0–9·0; and 13·0–15·0 mm. from the apex of the root. Each zone was cut into five 0·4-mm. fragments. The groups of sections were placed in petrol ether, stored overnight at + 4° C., and then washed, and ground with a glass pestle and mortar. 2·0 ml. of glass-distilled water was added and the resulting suspension centrifuged at approximately 5,500 *g* for 45 min. Finally, the clear supernatant was diluted 5,000 times with glass-distilled water.

Silver-plated grids with 'Formvar' films were used as carriers in the electron microscope. A drop of fluid was transferred to the grid, and, after drying under reduced pressure in a vacuum desiccator over phosphorus pentoxide, the preparations were gold shadowed and examined in a Phillips electron microscope. Photographs were taken by Mr. G. W. Ripley at a magnification of × 20,000. The particle-size was measured after projecting the electron micrographs on to a screen.

The accompanying photograph shows a typical electron micrograph of particles from the apical zone of the root. Measurements showed average diameters for the particles from the three zones of 0–2·0, 7·0–9·0 and 13·0–15·0 mm., of 37 mμ, 24 mμ and 20 mμ, respectively. Clearly, the particles are largest in the meristematic cells and tend to decrease in size as the cell matures. It was found that a similar change occurred when fragments are excised and cultured on water at 25° C. for 48 hr. During culture the average diameter in tissue from the apical zone decreased from 36 to 28 mμ, and in the 13·0–15·0-mm. zone from 20 to 13 mμ.

Since particles similar to those described above have been found by earlier workers[1–3] to be composed of ribonucleoprotein, the effects of trypsin, pepsin and ribonuclease on the bean root particles were investigated. Trypsin (B.D.H. reagent) was used at a concentration of 1 : 5,000 in an extract adjusted to *p*H 8·0 with ammonium hydroxide; pepsin (B.D.H. reagent) at the same concentration but in an extract brought to *p*H 2·0 with hydrochloric acid; and ribonuclease (purified Armour Laboratories) at 1 : 10,000 in an untreated extract. Aliquots were incubated at 25° C. for 3, 8 and 21 hr. in each case with and without the enzyme. Extracts from the zone 0–2·0 mm. from the tip were used for these experiments.



Electron micrograph of cytoplasmic particles in aqueous extract of region 0–2·0 mm. from apex of bean root. Magnification on print, × 30,000

With the exception of the extract treated with trypsin, particles were present in all preparations even after 21 hr. incubation. With trypsin there was little change during the first 3 hr., but a marked change after 8 hr. At the end of 8 hr. incubation the particles had almost entirely disappeared. A similar effect was observed in the extract treated for 21 hr. with trypsin. These observations suggest that the particles are composed of protein. The result with ribonuclease does not eliminate the possibility that they may also carry ribonucleic acid. If the skeletal framework is protein, removal of ribonucleic acid may not affect the overall size.

It is probable that the particles are structural components of the cytoplasm. Their significance in the metabolism of the cell is not yet known. It may be noted, however, that the change in size accompanies corresponding changes in the rate of increase of protein and in the activities of certain enzyme systems.

Further work on the chemical composition and metabolic activity of the particles is in progress, and a detailed account will be given elsewhere.

We thank Dr. R. D. Preston for facilities for using the electron microscope and Mr. G. W. Ripley for technical assistance.

E. Robinson
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Oct. 23.

[1] Claude, A., *Science*, **97**, 451 (1943).
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Effect of Thyroid Gland on the Cultivation of *Amœba proteus*

A preliminary study of the effects of thyroid gland tablets on *Amœba proteus*, placed singly or in bulk in hollowed-out glass squares, having been made without any definite results, the whole of the resulting material was used for inoculating culture 12, boiled wheat grains being the pabulum. For many months the *p*H of this culture fluctuated around *p*H 4, and *Euglena* flourished. Bean and pea cotyledons were substituted as pabulum. Small amœbæ, length 10–20 μ, were now present in culture 12. Miguel's fluid was added and the *p*H rose to *p*H 6·2. After a few months had elapsed, adult *A. proteus* appeared, and culture 12 was so flourishing that it was divided up into sub-cultures. These cultures are readily distinguished from our stock cultures even by a biologist quite ignorant of their history by: (1) the larger size of the adult amœbæ in them, (2) the persistence of the adult stage beyond the normal span (the time occupied by the amœbæ to grow from newly hatched to sporulation stage is twelve months); and, therefore, (3) the rarer occurrence of developmental stages in the culture; (4) difficulty in making successful sub-cultures from the original.

Dr. T. G. Rennie having kindly procured thyroid tablets of the same strength as those used above, the experiments are being continued to see if a race of 'giant' *A. proteus* can be secured.

Monica Taylor

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Aug. 5.

University Botanical Teaching and Training

The report of the discussion on botanical teaching held at the British Association meeting this year raises a number of interesting problems[1]. I cannot agree with Dr. Ashby when he suggests that the specific requirements of potential employers, and, in particular, government departments, should determine the scope and content of honours courses. I have heard similar arguments out here in New Zealand where government departments form the major avenue of employment for the abler students. It is surely our duty to see that students have a sound botanical, rather than a vocational botanical, training.

After acquaintance with several types of botanical training, and at the risk of appearing biased, I believe that something along the lines of the Cambridge system, as described by Prof. Briggs, meets several of the points raised and in particular has sufficient flexibility for the future specialists without losing the advantages to be gained from an overall education. The introduction of the half subjects, although regarded with suspicion by many at first, has, I think, been a happy proposal because it permits specialists to have a wider choice of ancillary subjects. I was surprised that no one raised the desirability of altering the present system in British universities where a subject tends to be studied as a unit over a whole year. The Cambridge half-subject system or the American semester system would merit much closer study in relation to the needs of present-day botanical teaching.

It might be of interest to refer to some organizational points at Auckland University College. Although there is no honours degree at the bachelor level, nevertheless the teaching is at the honours level. Certain prerequisites are laid down by the various heads of departments. Thus in botany a student who intends to study the subject for more than one year must do a year of chemistry before proceeding to study additional plant physiology. Any student taking the B.Sc. degree with botany as the major unit must, in addition, do one year in zoology. Those students who stay on to take an M.Sc. have not only a thesis to do but also there are additional lecture courses. These comprise formal courses in economic botany, history of botany and evolution, together with a number of topics selected from various fields of botany and changing from time to time. There are further prerequisites also; for example, a student specializing in genetics must have done a year of mathematics, a student in plant physiology is expected to have done a second or third year in chemistry, while an ecologist must attend a surveying course in the Geography Department. We also make use of specialists in other fields; for example, the professor of organic chemistry and the professor of geography both give some lectures in the course of economic botany.

Finally, the unit system at Auckland has great advantages, though it is not quite so flexible as the Cambridge system. Only one subject is studied over three years and at least one other subject over two years. This provides five units, and as eight are required for the degree the remainder can be taken as one-year courses in three other different subjects, or another subject can be taken to the second-year stage or one to a third-year stage. While this system provides very considerable flexibility, one must admit that it does raise time-table problems, though these can be solved.

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Dec. 10.

[1] *Nature*, **170**, 770 (1952).

The main difficulty in botanical teaching lies in the fact that three or even four years of study are not enough to train a biologist for all the requirements of modern life.

In this Department the first year is devoted to a general survey, necessitated by the completely insufficient knowledge the students bring with them from the schools. Thereafter students may proceed with zoology as second major; but chemistry as second major is becoming increasingly popular. As I consider any specialization in the first three years to be undesirable, I think it would be better if those majoring in botany and zoology could have the opportunity of following biochemical courses in case their interest lies in this field.

In the second year, courses in systematics of lower and higher plants and in physiology are given. In the third year, the main courses are those in taxonomy, anatomy, cytology and plant breeding; but there are also short courses in ecology, and in phytogeography in relation to climatology. Practical ecology is taught during a fortnight's course at Frankenwald, the University's Pasture Research Station.

Students proceeding to the honours course (fourth year) find no prescribed syllabus. Considerable choice of subjects is made according to their special interests. The system is one of individual tuition and serves three purposes: (*a*) extension and broadening of knowledge in some of the fields studied in the first three years, (*b*) self-activity, by learning how to tackle problems and apply different techniques with criticism, (*c*) discovery of abilities. A course of this type stimulates the interest of the student, not only in his own work, but also in that of others.

In conformity with the principle of general biological training in the first three years, which is based upon the undeniable interrelationship of all facets of modern botany, we created a special honours course in 'bio-ecology'. This course is based on botany and zoology as majors and has ancillary subjects like surveying, statistics and geology.

Subjects like ecology and other border-line fields are very suitable to demonstrate the complexity of apparently simple problems.

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Dec. 16.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 16

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5 p.m.—Mr. F. C. Meade: "An Approach to the Economics of P.O. Engineering Training".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Dr. E. C. Willatts and Mrs. M. G. C. Newson: "Pattern of Population Trends in England and Wales".

SOCIETY OF CHEMICAL INDUSTRY, CROP PROTECTION PANEL of the AGRICULTURE GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Papers on "Physical Factors in relation to Biological Activity of Insecticides".

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. T. S. Work: "Biosynthesis of Proteins".* (Further Lecture on February 20.)

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (at the Royal Institution, 21 Albemarle Street, London, W.1), at 6 p.m.—Mr. J. E. Cummins: "The Development of Chemistry in Australia" (Jubilee Memorial Lecture).

SHEFFIELD METALLURGICAL ASSOCIATION (joint meeting with the LOCAL SECTION of the INSTITUTE OF METALS, and the SOCIETY OF ENGINEERS AND METALLURGISTS, in the University Building, St. George's Square, Sheffield), at 7 p.m.—Mr. W. A. Baker: "The Constitution and Properties of some Titanium-Base Alloys".

Tuesday, February 17

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (in the Chemistry Lecture Theatre, Royal College of Science, South Kensington, London, S.W.7), at 2.30 p.m.—Dr. A. Eden: "Substitute Feeding Stuffs".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Prof. A. J. S. Pippard: "The Behaviour of Engineering Structures". (Further Lectures on February 24 and March 3.)

PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (joint meeting with the INSTITUTE OF REFRIGERATION, at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Discussion on "Novel Refrigeration Cycles".*

UNIVERSITY OF LONDON (in the Electrical Engineering Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. M. V. Wilkes: "The Design of Electronic Digital Computers".* (Further Lectures on February 24, March 3 and 10.)

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. A. H. Yates: "Recent Developments in Gliding".

ROYAL SOCIETY OF MEDICINE, PATHOLOGY SECTION (at 1 Wimpole Street, London, W.1), at 7.45 p.m.—Symposium on "Hæmoglobin Metabolism".

Wednesday, February 18

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (joint meeting with the NEWCASTLE SECTION of the S.C.I., and the CHEMICAL ENGINEERING GROUP, in the Stephenson Building, King's College, Newcastle-upon-Tyne), at 2.30 p.m.—Dr. W. H. J. Vernon: "Some Recent Progress in Corrosion Research"; at 6 p.m.—Mr. K. A. Spencer and Dr. H. B. Footner: "Protective Coatings for Buried Pipelines".

PHYSICAL SOCIETY, COLOUR GROUP (at the Institute of Ophthalmology, Judd Street, London, W.C.1), at 3.30 p.m.—Scientific Papers.

EUGENICS SOCIETY (at Manson House, 26 Portland Place, London, W.1), at 5 p.m.—Prof. T. H. Marshall: "Social Selection in the Welfare State" (Galton Lecture).*

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Scientific Papers.

PHYSICAL SOCIETY, ACOUSTICS GROUP (at the Science Museum, Exhibition Road, London, S.W.7), at 5.15 p.m.—Mr. D. H. Follett: Demonstration of some Old Instruments—Musical and Otherwise—from the Acoustics Collection in the Science Museum.

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Dr. M. H. F. Wilkins: "The Performance of Spherical-Mirror Reflecting Objectives when used for Ultra-Violet Photomicrography".

UNIVERSITY OF LONDON SCHOOL OF PHARMACY (in the Chemistry Lecture Theatre, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Sir Henry Dale, O.M., F.R.S.: "The Future of Pharmacy and Pharmacology" (Charter Lecture).*

INSTITUTION OF ELECTRICAL ENGINEERS (at Central Hall, Westminster, London, S.W.1), at 6.30 p.m.—Mr. A. R. Cooper: "Light from the Dark Ages, or the Evolution of Electricity Supply" (Faraday Lecture). (Admission by ticket obtainable from the Institution.)

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (joint meeting with the BRITISH ASSOCIATION OF CHEMISTS, at the Wellcome Research Institution, 183 Euston Road, London, N.W.1), at 6.30 p.m.—Prof. C. K. Ingold, F.R.S., and others: A Discussion on "Education in Chemistry".*

INSTITUTE OF PETROLEUM, STANLOW BRANCH (joint meeting with the NORTH-WESTERN SECTION of the INSTITUTE OF FUEL, at the Grosvenor Hotel, Chester), at 7.30 p.m.—Mr. S. J. Young: "Methane at Point of Ayr Colliery".*

Thursday, February 19

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 4.45 p.m.—Prof. V. B. Wigglesworth, F.R.S.: "Chemical Aspects of Insect Physiology".* (Further Lectures on February 26, March 5 and 12.)

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. J. S. Sheppard: "Precise Azimuths from Steep Sights": Mr. R. Daniel: "Diamond Mining Practice in Kimberley, South Africa".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Captain Cyril Diver, and others: "Nature Conservancy".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. G. de Rham: "On some Plane Curves which are defined by certain Functional Equations".

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Mr. V. W. Turner: "Village Structure of the Mwimlinga Lunda".

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (at the Building Centre, Store Street, London, W.C.1), at 6 p.m.—Dr. B. H. Knight: "The Stability of Asphalt Mixtures as affected by Aggregate Size".

ROYAL SOCIETY OF TROPICAL MEDICINE and HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. M. A. C. Dowling: "The Malaria Eradication Experiment in Mauritius".

UNIVERSITY OF LONDON (in the Swanley Hall, Wye College, Wye, Ashford), at 8.15 p.m.—Prof. W. Arthur Lewis: "The Economic Development of Under-developed Countries".*

Friday, February 20

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—Capt. R. C. Alabaster: "Navigation and the Operation of Jet Aircraft".

INSTITUTION OF MECHANICAL ENGINEERS (joint meeting with the APPLIED MECHANICS GROUP, at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Dr. K. H. R. Wright: "An Investigation of Fretting Corrosion".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Dr. D. P. Cuthbertson: "Problems of Quality and Quantity of Protein".*

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, Victoria Embankment, London, W.C.2), at 6 p.m.—Discussion on "Circuit Conventions, with particular reference to Alternating-Current Circuit Vector Diagrams" (to be opened by Mr. J. G. Fleming).

BRITISH INSTITUTE OF RADIOLOGY (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 6.30 p.m.—Mr. A. Nemet and Mr. W. B. Cox: "The Contrast Problem in High Kilovoltage Radiography".

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Scientific Papers.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Rt. Hon. Lord Brabazon of Tara: "The Birth of Flight".

Saturday, February 21

BIOCHEMICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 11 a.m.—Symposium on "Biological Transformations of Starch and Cellulose".

BRITISH PSYCHOLOGICAL SOCIETY (in the Psychology Department, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Dr. Clarence H. Graham: "Psychology in Japan".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

INSPECTOR (with a good honours university degree in physics or biology, and teaching experience) OF SCHOOLS (General) in the Ministry of Education for Northern Ireland—The Secretary, Civil Service Commission, Stormont, Belfast (February 19).

LECTURER IN AGRICULTURAL CHEMISTRY—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Square, Edinburgh (February 20).

ASSISTANT RESEARCH BIOLOGIST—The Secretary and House Governor, Mount Vernon Hospital, Northwood, Middx (February 21).

CHIEF CHEMIST OF THE COKE OVEN INSTALLATION at Nantgarw, near Cardiff—The Divisional Establishment Officer, National Coal Board, South-Western Division, Cambrian Buildings, Mount Stuart Square, Cardiff (February 21).

ASSISTANT LECTURER or DEMONSTRATOR (with a good honours degree in chemistry or biochemistry) IN CHEMICAL PATHOLOGY—The Registrar, The University, Manchester 13 (February 28).

ASSISTANT LECTURER OF LECTURER IN THE DEPARTMENT OF ELECTRIC POWER ENGINEERING—The Registrar, The University, Liverpool (February 28).

DEPUTY CHIEF MECHANIZATION ENGINEER (Ref. TT/590), and MECHANIZATION ENGINEERS (2) (Ref. TT/591), in the Mechanization Branch of Production Department at London headquarters—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting the appropriate Ref. No. (February 28).

LECTURER (Grade III or II) IN EXPERIMENTAL PHYSICS—The Registrar, The University, Bristol (February 28).

SCIENTIFIC or SENIOR SCIENTIFIC OFFICER (Ref. G.35/53A) to assist in ante-mortem and post-mortem investigations on quality of meat, and a SENIOR SCIENTIFIC OFFICER (Ref. G.36/53A) for investigation on general microbiology of foodstuffs, at the Low Temperature

Research Station, Cambridge—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No. (February 28).

Senior Lecturer in Pure Mathematics—The Registrar, The University, Sheffield (February 28).

Readership in Biochemistry at University College—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 4).

Research Officer to the Division of Animal Health and Production, Sydney, to collaborate in the present programme of research in the mammalian skin and hair by means of tissue culture and grafting, together with histochemical, biochemical and biophysical methods—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 4139 (March 7).

Scientific or Senior Scientific Officer (with a first- or second-class honours degree in chemistry, physics or chemical engineering) for research in physical, physico-chemical and biochemical problems on the preservation of fish, at the Food Investigation's new Humber Laboratory, Hull—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.32/53A (March 7).

Senior Research Worker to assist with the development of researches into family and community organization on Merseyside, and a Research Worker to assist with the development of researches in the industrial field on Merseyside—The Registrar, The University, Liverpool (March 7).

Chair of Physics at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 9).

Deputy Director of Research—The Director of Research, British Leather Manufacturers Research Association, Milton Park, Egham, Surrey (March 9).

Lecturer in Engineering—The Registrar, University College, Cathays Park, Cardiff (March 14).

Lecturer in Psychological Medicine—The Secretary of University Court, The University, Glasgow (March 14).

Lecturer or Assistant Lecturer in Botany (with special interests in taxonomy and morphology) at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (March 14).

Scientists (with good honours degree or equivalent) in the Physics Department—The National Coal Board, Central Research Establishment, Stoke Orchard, Cheltenham, quoting TT/592 (March 14).

Senior Agricultural Economist (Farm Management Liaison Officer) and an Agricultural Economist, in the Provincial Agricultural Economics Service of the Department of Agricultural Economics—The Registrar, University College, Aberystwyth (March 14).

Nuffield Research Fellowships and Assistantships in the Department of Genetics for research on microbial genetics—The Secretary of University Court, The University, Glasgow (March 15).

Professor of Pharmacology—The Deputy Secretary, Royal College of Surgeons of England, Lincoln's Inn Fields, London, W.C.2 (March 16).

Regius Professor of Logic in the University of Aberdeen—The Private Secretary, St. Andrew's House, Edinburgh 1 (April 1).

Research Assistant to the Professor of Medical Chemistry in the John Curtin School of Medical Research—The Secretary, London Office of the Australian National University, 27 Russell Square, London, W.C.1 (April 30).

Assistant Lecturer in Physiology and Pharmacology—The Registrar, The University, Nottingham.

Electrical Engineers at a Ministry of Supply Research Establishment near Sevenoaks: (*a*) for development work on electrical components, (*b*) for trials of experimental equipment, (*c*) for development of electromechanical devices—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.20/53A.

Engineers in the Post and Telegraphs Department, Nigeria—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.108/14/05.

Lecturer (Grade I) in Mechanical Engineering, and a Lecturer (Grade II) in Mechanical Engineering—The Registrar, The University, Nottingham.

Regional Trials Officer (with degree in botany or agriculture or equivalent qualification, and practical experience in crop production) for work possibly at Cambridge—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

Scientific Officers at Capenhurst: for molecular theory of gases and applied fluid dynamics (Ref. 411), and for aerodynamics of compressors and high-speed machinery development (Ref. 412)—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting the appropriate Ref. No.

Senior Electrical Engineer in the Public Works Department, Sudan—The Sudan Agent in London, Sudan House, Cleveland Row, London, S.W.1, endorsed 'Senior Electrical/Engineer 1818'.

Senior Lecturer in Chemistry (with qualifications and experience in organic chemistry) at Bradford Technical College—The Director of Education, Town Hall, Bradford.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

British Engine Boiler and Electrical Insurance Co., Ltd. Technical Report, New Series, Vol. 1. Pp. 212. (Manchester: British Engine Boiler and Electrical Insurance Co., Ltd., 1952.) 12*s.* 6*d.* [112

City and Guilds of London Institute. Report of the Council for the Year 1951. Pp. 64. (London: City and Guilds of London Institute, 1952.) [112

Proceedings of the BTH Second Summer School in Electrical Engineering. Pp. 212. (Rugby: British Thomson-Houston Co., Ltd., 1952.) [112

Ministry of Supply. Radioisotope Techniques: Proceedings of the Isotope Techniques Conference, Oxford, July 1951, sponsored by the Atomic Energy Research Establishment. Vol. 2: Industrial and Allied Research Applications. Pp. iv+177+33 plates. (London: H.M. Stationery Office, 1952.) 25*s.* net. [112

Other Countries

Pontificiæ Academiæ Scientiarum. Scripta Varia 10: Studio fisico dell'aorta normale e patologica. Per Vittorio Dal Borgo. Pp. iv+106. (Vatican City: Pontificia Academia, 1952.) [2611

Proceedings of the United States National Museum. Vol. 102, No. 3291: Contributions to the Morphology and Taxonomy of the Branchiopoda Notostraca, with special reference to the North American Species. By Folke Linder. Pp. 69+7 plates. Vol. 102, No. 3293: Some Marine Asellate Isopods from Northern California, with Descriptions of Nine New Species. By Robert J. Menzies. Pp. 117–159. Vol. 102, No. 3297: A New Crayfish from Alabama, with Notes on *Procambarus leconteï* (Hagen). By Horton H. Hobbs, Jr. Pp. 209–219. Vol. 102, No. 3299: A New Species of Commensal Amphipod from a Spiny Lobster. By Clarence R. Shoemaker. Pp. 231–234. Vol. 102, No. 3301: An Emended Diagnosis of the Copepod Genus *Pupulina* (Caligoida), with Descriptions of New Species and a Redescription of the Genotype. By Mildred Stratton Wilson. Pp. 245–263. Vol. 102, No. 3302: Echinoderms from the Marshall Islands. By Austin H. Clark. Pp. 265–303. Vol. 102, No. 3306: The Sipunculid Worms of California and Baja California. By Walter Kenrick Fisher. Pp. 371–450. Vol. 102, No. 3307: *Schizostella*, a New Genus of Brittle-Star (Gorgonocephalidæ). By Austin H. Clark. Pp. 451–454. (Washington, D.C.: Government Printing Office, 1952.) [2711

Smithsonian Miscellaneous Collections. Vol. 117, No. 13: Primitive Fossil Gastropods and their Bearing on Gastropod Classification. By J. Brookes Knight. (Publication 4092.) Pp. iii+56+2 plates. (Washington, D.C.: Smithsonian Institution, 1952.) [2711

Fieldiana. Botany, Vol. 26, No. 1: Orchids of Guatemala. By Oakes Ames and Donovan Stewart Correll. Pp. xiii+395. 4 dollars. Zoology, Vol. 34, No. 5: A Collection of Birds from Mount Cameroon. By Rudyerd Boulton and A. L. Rand. Pp. 35–64. 40 cents. (Chicago: Chicago Natural History Museum, 1952.) [112

Commonwealth of Australia: Department of External Affairs. Australian National Antarctic Research Expedition. A.N.A.R.E. Reports, Series B, Vol. 1, Zoology. The Fleas of Sea Birds in the Southern Ocean, by B. de Meillon; The Ticks of Sea Birds, by F. Zumpt. Pp. 20. (Melbourne: Antarctic Division, Department of External Affairs, 1952.) [112

Instituto Ecuatoriano de Ciencias Naturales. Contribución No. 21: Las fibras y lanas vegetales en el Ecuador. Por Prof. Dr. M. Acosta Solio. Pp. 80. (Quito: Casa de la Cultura Ecuatoriana, 1952.) [112

Geologisches Jahrbuch für das Jahr 1950. Herausgegeben von den Geologischen Landesanstalten der Bundesrepublik Deutschland. Band 66. Pp. lxxxi+750. (Hannover: Amt für Bodenforschung, 1952.) [112

Proceedings of the United States National Museum. Vol. 102, No. 3292: A Study of an Intermediate Snail Host (*Thiara granifera*) of the Oriental Lung Fluke (*Paragonimus*). By R. Tucker Abbott. Pp. 71–116+plates 8–9. (Washington, D.C.: Government Printing Office, 1952.) [412

Smithsonian Miscellaneous Collections. Vol. 117, No. 17: A Generic Synopsis of the Lizards of the Subfamily Lygosominæ. By M. B. Mittleman. (Publication 4096.) Pp. ii+35. (Washington, D.C.: Smithsonian Institution, 1952.) [412

Development of International Cooperation in Science: a Symposium held in conjunction with the Third Annual Meeting of the Executive Board, International Council of Scientific Unions, October 18, 1951, Washington, D.C. Pp. 28. (Washington, D.C.: National Academy of Sciences—National Research Council, 1952.) [412

Annual Report for 1951 of the Chemical Division of the Rubber Research Institute of Malaya. Pp. 26. (Kuala Lumpur: Rubber Research Institute of Malaya, 1952.) [912

University of Natal: Wattle Research Institute. Report for 1951–1952 (Fourty-fifth Year). Pp. 76. (Pietermaritzburg: University of Natal, 1952.) [912

Transactions of the Danish Academy of Technical Sciences. A.T.S. 1952, No. 2: Some Experiments with Sleeve Bearing Metals. By Børge Lunn. Pp. 144. (København: G. E. C. Gad, 1952.) 18*kr.* [1012

Union Géodésique et Géophysique Internationale: Association Internationale d'Hydrologie Scientifique. Assemblée générale de Bruxelles 1951. Tome 1: i. Partie générale et administrative; ii. Rapports sur l'activité; iii. Rapports et comptes rendus des Séances de la Commission des Neiges et Glaces. (Publication No. 32.) Pp. 358. 300 francs. Tome 2: i. Rapports et comptes rendus des Séances de la Commission d'Érosion du Sol; ii. Rapports et comptes rendus des Séances de la Commission des Eaux Souterraines. (Publication No. 33.) Pp. 302. 250 francs. Tome 3: Rapports et comptes rendus des Séances de la Commission des Eaux de Surface. (Publication No. 34.) Pp. 520. 350 francs. Tome 4: Symposia sur les Zones Arides et les Crues. (Publication No. 35.) Pp. 200. 125 francs. (Bruxelles: Association Internationale d'Hydrologie Scientifique, 1952.) [1012

Catalogues

Matched Load, 3·2 cm. Waveband; Matched Load, 8·9 mm. Waveband. (Publication MW. 1–2). Pp. 2. Rotary Attenuator, 8·9 mm. Waveband. (Publication MW.3a.) Pp. 2. (London: Elliott Brothers (London), Ltd., 1952.)

Correct X-Ray Film Processing by Fully Automatic Control. Pp. 4. (London: Nucleonic and Radiological Developments, Ltd., 1952.)

Catalogue of Books on Mathematics, Physics, Astronomy and Meteorology. Pp. 52. (London: H. K. Lewis and Co., Ltd., 1952.)

Bowl Functioning Principles of the Sharples Super-Centrifuge. (Bulletin 452.) Pp. 4. (Stroud: Sharples Centrifuges, Ltd., Woodchester, 1952.)